Materials in Design Engineering

ORMERLY
ATERIALS
METHODS

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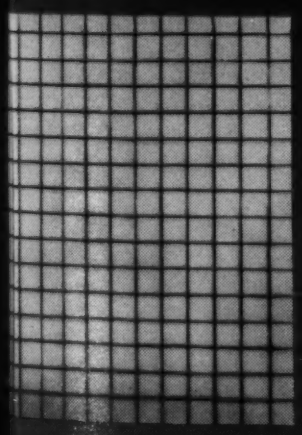
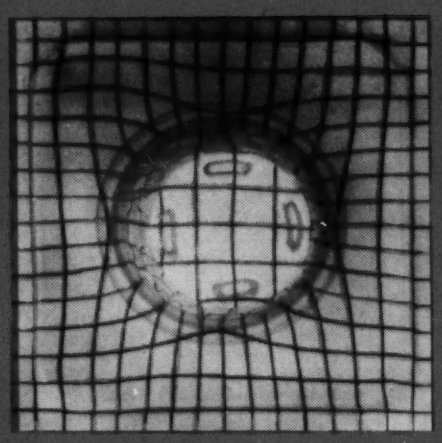
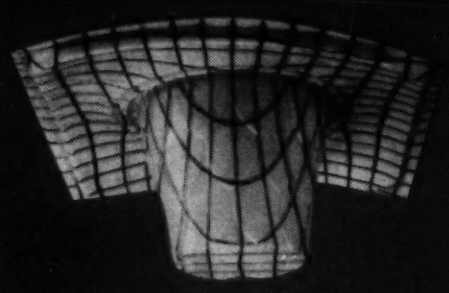
ELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES







Also:

Precision Forgings

How to Evaluate Organic Coatings

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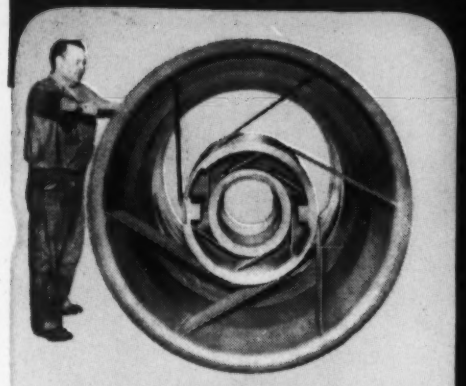
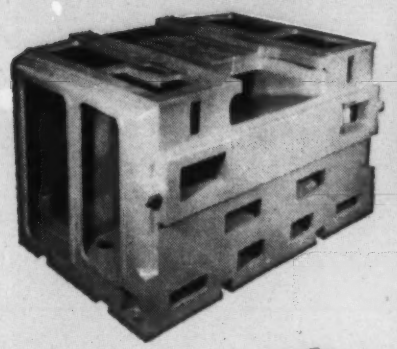
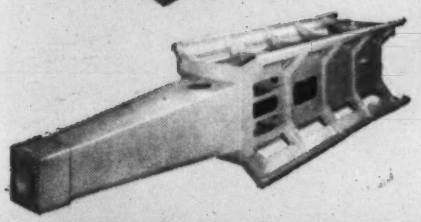
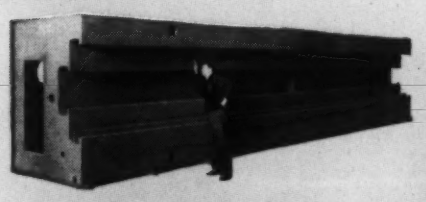
Sheet Formed Plastics Parts | Manual No. 154

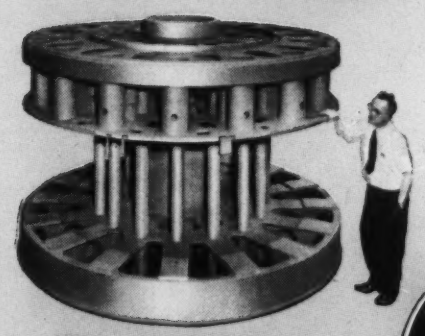
Preview: Plastics Show

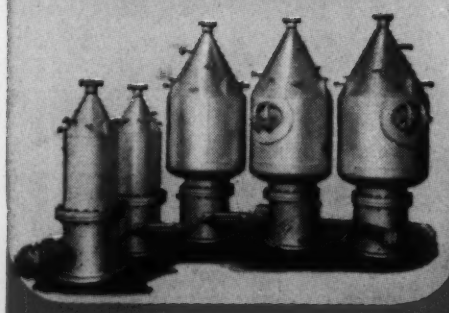






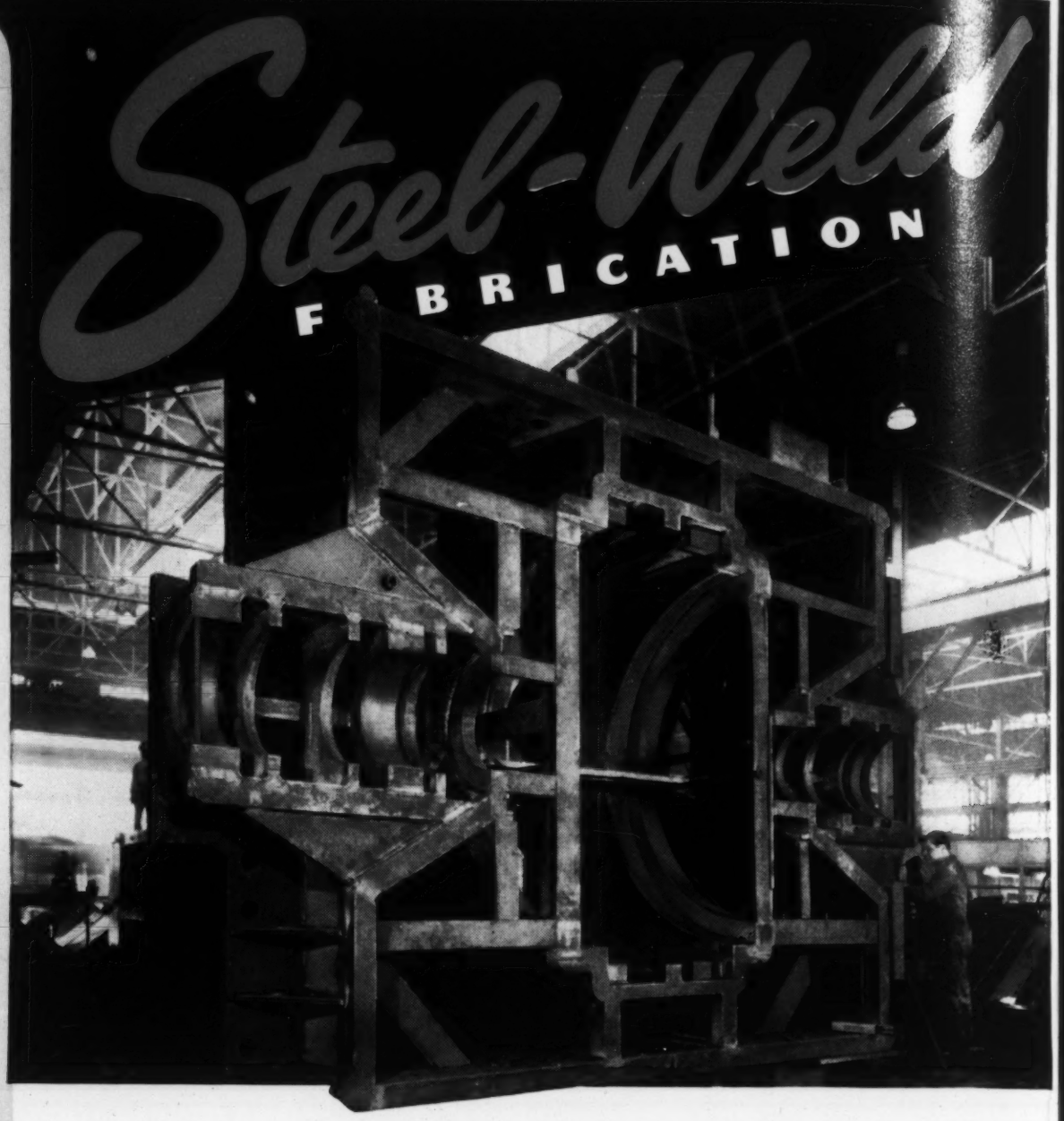






Steel-Weld

FABRICATION



Use WELDED STEEL for Greater Strength with Less Weight!

The 100-ton weldment illustrated above is the base unit of a housing for a 300,000 kw Steam Turbine. It is another example of Mahon craftsmanship and Mahon's ability to serve you. This heavy weldment, and those appearing at the left, are typical of the thousands of Steel-Weld Fabricated Parts and Assemblies produced by Mahon each year for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. If you are not now taking full advantage of the economies offered by welded steel components in your product, you should give the matter serious thought. In the design of almost any type of heavy machinery, or mechanical engineering project, there are parts and sub-assemblies that can be produced more economically, more satisfactorily, and in less time, in welded steel. In weldments you get greater strength with less weight—plus the additional advantages of greater rigidity and 100% predictability. When you consider weldments, you will want to discuss your requirements with Mahon engineers, because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill is backed up by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

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Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

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Materials in Design Engineering

formerly Materials & Methods

Selection & use of metals, nonmetallics, forms, finishes

NOVEMBER 1958
VOL. 48, NO. 6

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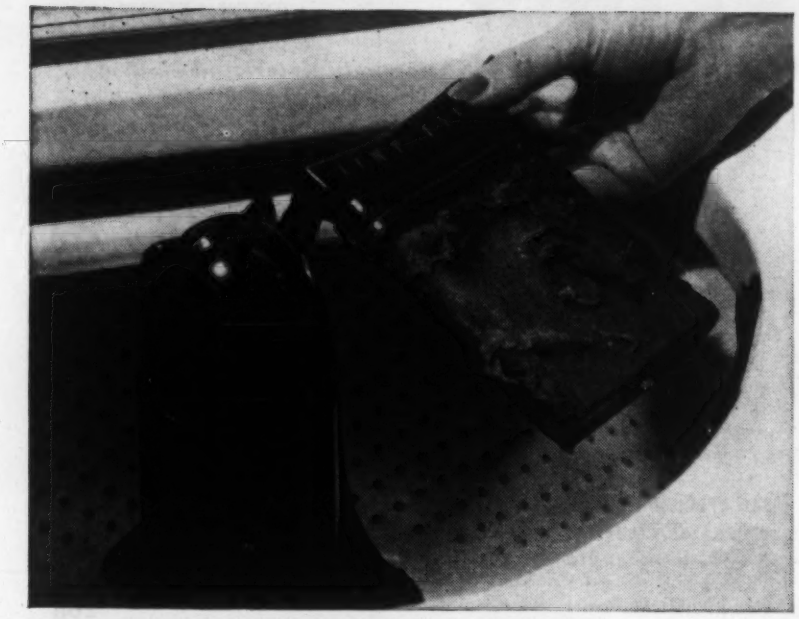
COVER BY HARRY & MARION ZELENKO; PLASTICS PART COURTESY PHILLIPS CHEMICAL CO.

Inco Nickel Alloys
. . . for wire mesh in severe environments



For corrosion, abrasion resistance

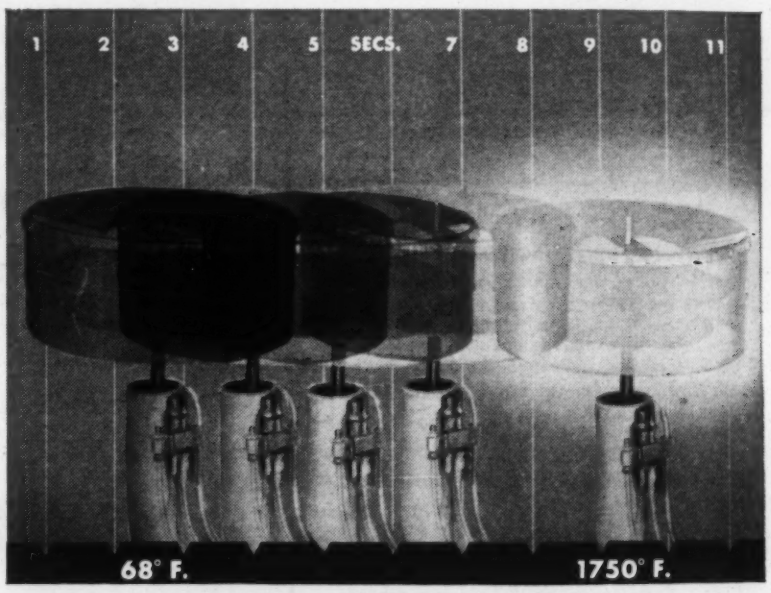
This lint filter is a big reason why housewives buy RCA® Whirlpool automatic washers. Made of a lightweight Monel* nickel-copper alloy mesh, it can withstand practically all household acid and alkaline solutions . . . stands up to clothes grit, too. Monel mesh is easily formed, brazed, welded. And . . . in fine meshes, it's priced especially low.

For high conductance, caustic resistance

The plates in long-lived nickel-cadmium batteries are sintered carbonyl Nickel powder reinforced with nickel wire mesh. Strong Nickel mesh is proof (1) against the high sintering temperatures used in plate manufacture (2) against embrittlement or corrosion from the potassium hydroxide electrolyte (3) against contamination by foreign ions.

For "hot" strength, oxidation resistance

At the Progressive Metal Treating Co., heat-treating trays lasted about 7 months — until they were made of Inconel* nickel-chromium alloy. These trays are used in carburizing, nitriding, annealing of small steel parts. They withstand heating to 1750°F, quenching to 150°F oxidation, in a gas fired furnace. After 30 months, trays are still in daily use.



For cyclical thermal shock

Radiant elements like this are fired from cold to 1750°F in 11 seconds—thousands of times! Incoloy* nickel-iron-chromium alloy element is part of a gas conversion burner made by the Abbott Equipment Co. Incoloy wire mesh stands up to thermal shock, high temperature oxidation and creep. Easy to form, braze, weld. Priced competitively with less durable materials.

*Registered trademark

*Use meshes of Inco Nickel Alloy to improve your product, cut manufacturing costs—check with your wire cloth supplier.***

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N.Y.

**Names on request

INCO NICKEL ALLOYS

For more information, turn to Reader Service card, circle No. 539

What's new IN MATERIALS

...AT A GLANCE

A HIGH STRENGTH ALLOY STEEL SHEET has been developed especially for large rocket and missile parts. According to the developer, missile parts made of the alloy can be air hardened to a tensile strength of 280,000 psi without the distortion that may occur when oil or water hardening is necessary. (More details next month.)

FILLED EPOXY ADHESIVES HAVE GOOD BOND STRENGTHS AT -420 F, according to recent government research. Tests show that the adhesives have about the same tensile strength at -420 F as they do at room temperature; shear strength shows a drop of about 50%.

ANOTHER ADHESIVE, A RUBBER-PHENOLIC, has a shear strength of 495 psi at 600 F, compared to 220 psi for other rubber-phenolic adhesives. The thermosetting adhesive is recommended for bonding rubber to metal, plastics to metal, metal to metal, and friction materials.

A PORCELAIN ENAMEL ADHESIVE shows promise for bonding stainless steel honeycomb structures at high temperatures. Still under evaluation, the adhesive has a thermal expansion approaching that of the base metal.

THIN-WALLED CERAMIC HONEYCOMB STRUCTURES now available can withstand 1800 F with virtually no thermal expansion. The structures can be made of any ceramic material (including Pyroceram, the high strength crystalline glass). Potential uses for the honeycomb structures include burner plates, catalyst supports and gaseous heat exchangers. (More details next month.)

BETTER WELDED STAINLESS STEEL PARTS can be obtained by first testing the metal for zinc particles left on the surface from certain types of forming dies. Zinc is detected by applying a chemical solution to the surface of the metal; if present, zinc will show up reddish purple. Welding heat causes zinc to penetrate into the grain boundaries and subsequently crack the metal.

A LUBRICATING, CORROSION RESISTANT TFE FILM can be applied to wood and other heat sensitive materials by using a colloidal dispersion of TFE resin. Applied by spray, the dispersion can be cured at 300 F or less. Formerly, TFE films could only be used on materials

What's new IN MATERIALS

that withstood sintering temperatures of 700 F. The TFE dispersion is expected to find use on extrusion dies, speedometer cables, skis, engine parts, farm machinery, door hinges and sliding closet doors.

ZINC FOIL in sizes from 0.005 to 0.001 in. thick is now available in developmental quantities. The foil is produced by a new technique in which zinc is deposited electrolytically from a zinc sulfate bath onto a revolving drum. The technique is said to produce foil of high chemical purity with good ductility and strength.

EPOXY RESINS WITH GREATER HEAT RESISTANCE have come out of the development of three new epoxy resin-producing chemicals. The resins have heat distortion temperatures of over 500 F, accompanied by good resistance to aging at such temperatures. The chemicals used look promising for laminating and casting resins, coatings, adhesives and foams. (More details next month.)

A NEW FAMILY OF SUPERCONDUCTORS has been discovered. The materials, uranium alloys, are said to be the first ever known to contain manganese and iron (two elements usually considered alien to the existence of superconductivity). At extremely low temperatures, the electrical resistance of the uranium alloys is about one-millionth of one-billionth (1×10^{-15}) of their normal value.

METAL SPUTTERING, a century-old coating technique, may be useful in producing printed circuits, recent research indicates. Metals such as titanium and tantalum, and alloys such as nickel-copper and nickel-chromium can be sputtered without difficulty. The technique is attractive for printed circuits because it eliminates the need for any organic adhesives.

BETTER WINDOW GLASS may be obtained by substituting small amounts of lithium for sodium in the glass, recent research indicates. Lithium is said to lower viscosity of molten glass, permitting it to be formed into sheets at lower temperatures and eliminating bubbles during forming. Lithium is also said to increase hardness, decrease thermal expansion and improve chemical stability of the finished glass.

NEW INORGANIC ELECTRICAL INSULATIONS have been developed for use in supersonic aircraft. Tests show the insulations perform well in a "red hot" motor operating intermittently at 1200 F and continuously at 950 F. The phase and slot insulation consists of flexible glass cloth and large mica flakes bonded with phosphate. The wire insulation consists of glass fibers impregnated with powdered mica in a phosphate solution.

Turn to page 141 for more "What's New in Materials"

MATERIALS BRIEFS

Battery-Powered TV

A tiny nickel-cadmium battery will be powering a portable TV set expected on the market early in 1959. Each cell in the battery consists of carbonyl nickel powder sintered to a perforated steel strip. The battery can be recharged by plugging into a wall socket.

Self-Supporting House

A build-it-yourself aluminum house that can be put together in a day is being marketed by an English firm. The house needs no frame, as strength is provided by corrugated aluminum sheets.

Replicas Show Wear

Plastics replicas are being used to study wear in places such as cylinder walls where direct observation is difficult. A sheet of cellulose acetate is dipped in dioxane and pressed against the wearing surface to make the replica. Gold is evaporated on to the sheet; wear is them observed under a microscope.

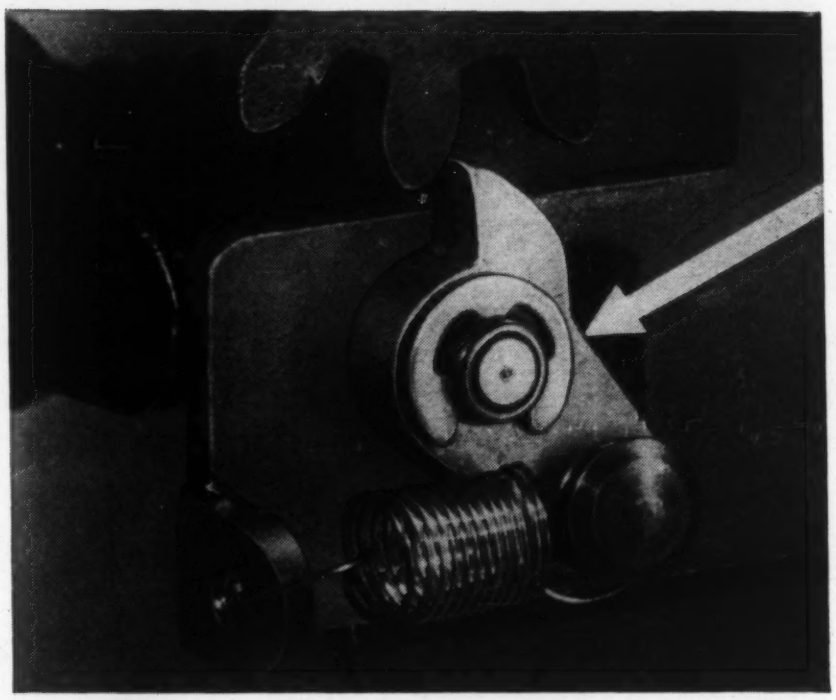
High Flying Stainless

An experimental rocket plane, scheduled for flight in 1959, is to have both airframe and skin of stainless steel. The plane is designed to fly at speeds of 3600 mph and at altitudes above 100 miles.

The Quiet Game of Golf

Rigid PVC tubes 33½ in. long have been introduced as golf club protectors. The tubes, said to fit any golf bag, keep clubs in place and stop them from banging against each other during the golfer's trip over the fairways.

WHERE CAN NONFERROUS POWDER METALLURGY HELP YOU MOST?



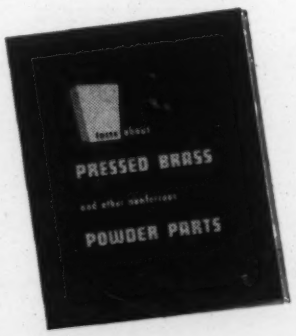
WHERE YOU NEED PERFORMANCE AND DURABILITY—AT LOW COST

Inside its handsome case where moving parts undergo constant action from the slide changer, the vital trip lever (see arrow) of this VIEWLEX Slide Projector is made of sintered NICKEL SILVER POWDER.

Here's what nonferrous powder metallurgy provides for many such stressed mechanical and structural parts:

. . . ***nonrusting without finishing***
. . . ***uniformity of dimensions***
. . . ***controlled hardness***
. . . ***faster assembly without machining***
. . . ***low unit cost***

A powder metal fabricator can show you how nonferrous powder metallurgy can provide the performance and durability you need in your products.



THIS BOOKLET

will assist you in evaluating this modern production method in terms of your particular needs.

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THE NEW JERSEY ZINC COMPANY
160 Front Street, New York 38, N. Y.

For more information, turn to Reader Service card, circle No. 495

B.F.Goodrich

QUALITY CONTROL

Instruments & Tests

A rigid quality control system is set up to insure that all material meets our or our customer's specifications. Samples from every batch are checked during processing and when completed. Incoming ingredients are also checked for quality.

Some of the instruments our well equipped laboratory uses are:

Abbe refractometer
Sartorius balance
pH meter
Melting point apparatus
Gravitometer
Brookfield viscometer
Microscope
Fadeometer
Weatherometer
Oxygen bomb
Ozone bomb
Ovens
Humidity cabinet
Mooney Plastometer
Scott Tensile Tester
Ozone cabinet

☆

Materials-Control Instruments and Tests

The Abbe refractometer is used to check the purity of plasticizing oils and solvents. The microscope with its screw micrometer eyepiece measures thickness of skin on automotive and other type strip. Viscosimeters check viscosity of oils, solvents and cements. Melting point apparatus and sieves check the purity of solids and their particle size. An analytical laboratory checks for traces of impurities which would affect the final product.

☆

Grades of Sponge Rubber

The American Society for Testing Materials is a national technical society composed of producers, consumers and members of interested groups such as research organizations, colleges, etc. In the past fifty years it has established a large number of standards and standard test methods on almost every type of material. We provide materials which meet the ASTM specifications recognized by many of our customers, including automotive, airplane, and other large manufacturers. ASTM designation D 1056-54T* is the specification number covering both cellular rubber testing methods and grades. This number in itself means nothing; the properties of the rubber are given by the letters and numbers in the tables of that specification. The prefix letters designate the type of rubber, i.e., R stands for rubber, either natural or synthetic, where oil resistance is not required. (Formerly this was RN for natural rubber and RS for synthetic). SC stands for rubber with good oil resistance, usually Neoprene, and SB for excellent oil resistance, usually a Nitrile rubber. The prefix letters are followed by numbers which denote the type (open or closed cell, or foam) and the firmness and by suffix letters (see page 25) when special qualities are required.

A standard test sample disc, 1 square inch in area and ½" in thickness, is used for testing. When possible this is cut from the part itself, but if the shape of the part precludes this, a standard ½" test slab is made from the same compound and tested.

*Formerly Specification D-798 and test methods D 552.

☆

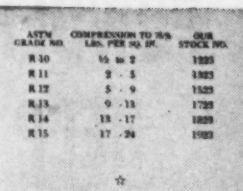
Compression

In compression the degree of firmness regulates to a great extent the type of sponge rubber that can be used for a given application so it is only natural that sponge rubber should be classified by its firmness. This has been done by the ASTM which has set up six grades based on the force necessary to compress a sample, one square inch in area, to 75 per cent of its original height. We manufacture sponge rubber to meet all of these grades. In addition, we have special compounds to meet the softer letter requirements, such as low temperature, high temperature, non-staining, adhesion, weathering, etc. These grades (for natural rubber) are given below, with our sheet stocks which correspond to them. A more complete list is found on page 24.

ASTM GRADE NO.	COMPRESSION TO 25% LBS. PER SQ. IN.	OUR STOCK NO.
R 10	½ to 2	1225
R 11	2 - 5	1323
R 12	5 - 9	1523
R 13	9 - 13	1723
R 14	13 - 17	1823
R 15	17 - 24	1923

☆

Graphs showing the complete compression — deflection curves of these stocks are given below.



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A sample disc, one square inch in area, is cut from every roll of sheet machine stock we manufacture. This is tested and graded by ASTM standards. Quality control graphs maintained on these tests show the compression, compression-set, aged compression change, density and thickness. These graphs are constantly watched by the Production Department to see that quality is maintained.

☆

For cord and molded goods, standard practice in the industry is to prepare and test a slab of the same compound. This is not always conclusive and therefore not entirely satisfactory. We have developed special tests that can be made on the finished product. Examples of these special test requirements are found on the many molded items we make. Automobile parts, such as weatherstripping, trunk seals and cowl gaskets are treated by applying sufficient force to compress a 12" length ½". Horn rings, bicycle seats, sponge bats and such are given special tests on the completed part, the type of test depending on the specific property most important for the application.

☆

Compression-Set

Rubber compressed for an extended period of time does not completely regain its original height. This loss in height is called "compression-set." This figure must be kept low or the rubber loses its ability to form a close seal.

We continually have requests from customers for information as to what set the rubber will take in their applications. These conditions of use vary as widely as the innumerable uses for sponge rubber. To get basic information we have run compression-set tests under different conditions of time and temperature on standard ½" samples. Thinner stocks may have poorer sets than those in a slab (seen due to the thickness of skin in relation to the total thickness. However, the test samples were taken from regular production and are representative of our product.

The standard compression-set test for sponge rubber is to compress the sample to 50 per cent between two steel plates. At the end of the test period, usually 22 hours at 158° F., but also run at room and other temperatures, and for varying periods of time, the sample is removed, allowed to rest for 30 minutes, and remeasured. The per cent loss in height is the compression-set figure.

In the ASTM method, the compression-set is figured as the per cent of the deflected height lost. This gives a figure just double that of the original height lost and has led to considerable confusion. Therefore, if the compression-set is given as an ASTM figure, just divide by two to get the actual % height loss.

Room Temperature

Our stocks show a remarkably low set at room temperature. After being compressed 50% for 48 hours, the average set of hundreds of samples is around 2-3 per cent. Graph II shows compression-set curves of two of our stocks over an eight year period. At the end of eight years, sets averaged between 30 and 35 per cent. This should be a convincing argument that these stocks could be used as gaskets or in compression for an extended period without losing their sealing properties.

Elevated Temperatures

The standard ASTM compression-set test is for 22 hours at 158° F. By this test our production stocks, when made into standard ½" ASTM test slabs, will be within the ASTM limits.

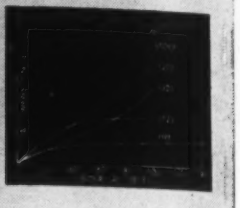
☆

As noted before, thin stocks, due to their fast cure and comparative skin thickness, tend to have higher sets.

At longer times or higher temperatures, compression-set increases. Although sponge rubber should not be used in compression at elevated temperatures where loss set to descend (as the rubber has a tendency to cure up to the new compressed position) it is possible to go beyond the two times and temperatures and still have some sealing properties left.

Graph III shows the change in compression-set over a period of 100 hours at 158° F. Our 1101 stock, especially compounded for high temperatures, was kept in compression for 7 days. At the end of this time, the set was under 10 per cent.

At temperatures of 200° F., for 22 hours, all stocks but 1101 have sets of over 40 per cent and at 46 hours regain only a few per cent of their compressed height. However, 1101 has a set of only 20 per cent after 46 hours at 200° F. Therefore, if a material is required which must have a low compression-set at higher than normal temperatures, our 1101 will give excellent results.



Influence of Heat and Aging

One of the most frequent questions we receive concerns the temperature range of sponge rubber. Will it stand two hours at 275° F., a month at 175° F.; steam, heat and cooling cycles, etc.? These questions are difficult to answer because conditions in actual use are always different. To obtain further information on this subject we ran our own complete compression-deflection curves on our ½" sheet stock at different times and temperatures.

High Temperature Aging

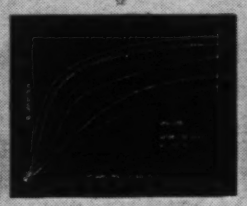
The standard seven days at 158° F. test has little effect on our sponge rubber. Therefore, we have run this test for 120 days — a solid four months in the oven. As a week at 158° F. is considered the equivalent of six months to a year of natural aging at room temperature (not exposed to sunlight) it can be seen that sponge rubber will be serviceable for years under normal room conditions.

Graph IV shows the change in compression after this test. The curves are roughly parallel — with a change in firmness averaging but a few per cent, usually between 5 and 10 per cent.

At higher temperatures sponge rubber hardens more rapidly. For example, 1223 stock at 200° F., as shown in Graph V, hardens but little after twenty days; is firmer, but still serviceable after forty days, and, at sixty days, is practically rubd. 1825 stock acts the same way.

☆

Stocks 1523, 1723 and 1823 contain compounding ingredients which add to their firmness and which are necessary to make them meet their ASTM classifications. These materials harden at elevated temperatures and, therefore, these stocks will not stand long periods at 200° F. Graph VI shows 1523 after twenty and forty days; 1723 and 1823 are similar.



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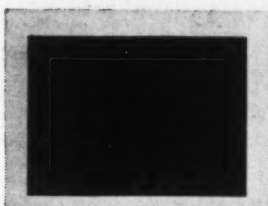
These pages and 18 more are yours for the asking



Other Aging Tests

In addition to the aforementioned aging tests, we use oxygen bomb and air-bomb tests; weatherometer or artificial weathering tests, and natural sun aging tests. The bomb tests are conducted at elevated temperatures at 90 psi air pressure or 300 psi oxygen pressure. Our stocks easily pass ASTM and government specifications for these tests. The weatherometer is a machine that subjects the rubber to a spray (rain), a stream of air (wind), and carbon arc light (sun). In 100 hours the material is given the equivalent of approximately six months in the open. By these means and by outdoor exposure tests on our roof and in Florida, we check our products constantly and continually strive to improve their aging qualities.

☆

Flexing

A standard ASTM flex test is to compress a piece of sponge rubber 250,000 times to 50 per cent. The loss in height, after one hour of rest, should be less than 10 per cent. We count this test easily in all stocks, usually having less than 5 per cent loss. Even a half-million flexes results in less than 10 per cent height loss. This is of great importance as it is one of the most valuable properties of sponge rubber. It means, for instance, that in vibration damping, the sponge rubber can be compressed millions of times without structural breakdown.

☆

Tensile and Elongation

As sponge rubber is used in compression, tensile strength is not the important property that it is with mechanical rubber. However, some companies still require a minimum value in their specifications. The tensiles of our crude rubber stocks are extremely good. It is hard to give definite figures because thin stocks, due to higher density, have higher tensiles than thick, lower density stocks. However, 1333 runs from 75-100 psi tensile and 500-600 per cent elongation up to ½" Tensiles and elongations then decrease to 30-50 psi and 350-450 for 1" stock. 1523 runs about the same in tensile with lower elongation and 1723 has a higher tensile average with elongation running to 300-400 per cent.

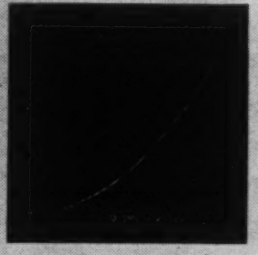
These values are taken at the breaking point, i.e., a 75 psi tensile and 500 per cent elongation mean that it would take 75 pounds to break a sample one square inch in cross-section and that the sample would stretch 500 per cent (a one inch length would stretch to six inches) before it breaks. The good tensiles and higher elongations of our sheet stocks mean that the sponge can be stretched considerably without breaking.

☆

Durometer

For many years the Shore Durometer "OO" has been used to check the softness of sponge rubber. Due to its convenience and speed, it is still used, although generally replaced by more accurate methods of testing compression. Different people will get different results on the same material, using the Durometer, and thin stocks will have a higher reading than thick (as in textile). Starting these facts in mind, we can say that 1323 stock falls in Durometer "OO" range of 25-45. 1523 averages 35-60, and 1723 falls between 45-70.

Many people use Durometer "A", made for mechanical rubber, and often ask how our values compare. Below is a graph comparing the two Durometers.



☆

This conversion graph is not to be considered accurate on all stocks as any surface hardness tester evaluates modulus at low elongation if the reading is taken immediately and modulus at low elongation plus plastic flow if an interval elapses before reading. Thus, not only the pressure used by the operator, but also the time he takes in making the reading, influences the result.

Insulation Value — Heat

The insulation value of a material is the property it possesses of slowing down the transfer of heat. This property can be measured and expressed in a number called the K factor. K factor is defined, in English units, as the amount of heat in B. T. U. (British Thermal Unit) which will flow in one hour through a square foot area 1" in thickness with a temperature gradient of 1° F. A B. T. U. is the amount of heat necessary to raise one pound of water one degree Fahrenheit.

Representative samples of sponge rubber have been tested and found to have a K factor of 0.66. This is higher than most insulating materials and much higher than our Cell-Tite, the non-interconnecting cell structure of which is responsible for a K factor of 0.20 to 0.25.

☆

Insulation Value — Sound

Sound insulation is a complex problem. There is no one value, like the K factor for heat insulation, which tells the whole story. The sound absorption coefficient and sound transmission coefficient are both used in acoustical measurements and of these the former is probably more useful as it can be compared with the published values of many other materials. We have had this sound absorption coefficient measured for our ½" 1223 by the Tube method. In this method a "wall" of sponge rubber is placed at one end of a tube and a sound of definite frequency introduced at the other. The sound waves travel through the tube and hit the rubber where some are absorbed and some are reflected. The reflected waves unite with the original waves and, at certain points where they meet in phase, reinforce them and produce a sound of maximum intensity. Where they meet out-of-phase a minimum sound is heard. These points are determined electronically and by use of a fairly simple formula the sound absorption coefficient is figured.

For our ½" 1223 these values are:

Frequency cycles per second	Sound absorption coefficient
256	0.800
512	0.310
1024	0.945
2048	0.900
3096	0.585

For normal auditorium acoustical problems, the coefficient of sound absorption at 512 cycles is commonly accepted. Sponge rubber is exceptionally good at absorbing the higher frequency tones.

The average of the sound absorption coefficients for 256, 512, 1024, and 2048 cycles per second is often used as the noise reduction coefficient. In the above case it would be 0.715.

☆

Staining and Tarnishing

There are three general types of staining: Discoloration of the stock itself, i.e., white rubber turning yellow; light blue darkening, etc.; contact stain, and migration stain. The first class does not prove too troublesome as we buy the best colors and compound for maximum color stability. Contact stain as defined by ASTM, occurs when rubber is in close contact with a lacquered or enameled plate under heat. Migration stain occurs when rubber is in contact with the plate under ultra-violet and heat. This is the most important test to us due to the many automotive parts we make.

A standard test for automotive staining originated by Fisher and adopted by ASTM, makes use of a lacquered panel exposed to ultra-violet rays of a sun lamp for a definite time and distance. By this test, none of our crude sheet stocks stain.

When in contact with wood or paper under room conditions, no stain occurs. However, different types of paint and lacquer will react differently and, in case of doubt, the customer should furnish a sample of the material he uses for us to use in making special tests.

Vinyl plastics, due to the stabilizer used, will generally be stained through action of the sulfur in the rubber. Sometimes a fabric backing on the vinyl prevents this.

Metals will usually be tarnished by continued contact with sponge, especially at elevated temperatures. This also is caused by the sulfur in the compound. For special cases we have a sulfur-free compound which will eliminate this trouble. Our 1423D, Sulfur Free Stock, was tested by inverting shiny dimes in slits in the rubber, and kept at 158° F. for 7 days. At the end of this period, there was no tarnishing and the dimes were bright. When tested in standard sulfur bearing sponge, the dimes were badly tarnished.

In addition to this compound, we have 1603, a low sulfur compound, especially made for being covered or in contact with vinyls. Sulfur bearing sponge often stains or discolors vinyl sheeting, especially the light colors. 1603 either eliminates or keeps this discoloration to a minimum.

Fungus Resistance

Natural rubber and the common man-made rubbers which we use are practically free from fungal attack. When growth occurs, it is usually due to foreign matter on the surface of the rubber. It is not necessary to add fungicidal materials to sponge under most conditions.

Termite Resistance

Like fungus resistance, rubber is to a great extent termite proof. This is of great importance to our many rug underlay customers. We have had extensive tests made by one of the country's largest laboratories whose conclusions are that it is possible for carpet beetles to reproduce on practically any surface, but on sponge rubber their growth was considerably retarded and larvae were much smaller than normal. Under these conditions, they would normally migrate in search of food.

☆

Resistance to Oils and Chemicals

We have many inquiries as to the effect of various chemicals on sponge rubber. The swelling or shrinkage of sponge rubber is an important property to be considered in many applications. If the sponge swells unduly, it becomes soft and mushy, without strength. The ASTM considers as "medium swell" one that increases less than 60 per cent in volume after 22 hours immersion at 158° F. and a "low swell" stock increases less than 10 per cent.

1101 Stock — for High Temperature Resistance

(Available on special order, minimum requirement necessary.)

Our high temperature stock No. 1101 is an extremely versatile material. Originally designed to give good heat resistance, it also has excellent compression-set and low temperature characteristics. By the standard ASTM method the compression-set ranges from a little over five per cent for 22 hours at 158° F. to less than ten per cent for 166 hours. At 200° F. the set is under 12 per cent for 22 hours and 20 per cent for 46 hours. Even under the extremely severe conditions of 72 hours at 225° F. the set averaged between 35 and 40 per cent.

At high temperatures 1101 stock can be used where standard rubber compounds fail. 200° F. — 225° F. have little effect on its softness even after 30 days. At 250° F., twelve days make little change, but at fifteen days the stock begins to harden, and at eighteen days it is very firm.

At 275° F. the limit of continuous use is between three and four days. At five to six days the stock is hard.

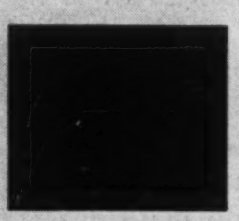
For low temperature resistance 1101 stock is surpassed only by 1343 in crude rubber compounds. At — 40° there is little hardening and at — 67° F. (— 55°C.) the change is not great, as is shown by Graph XVII.

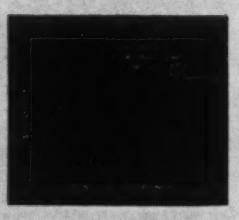
Silicone — for extremes of temperatures

For uses where continuous temperatures over 350° F. are unavoidable, or for extremes of both high and low temperatures, Silicone sponge and Silicone Cell-Tite (a closed cell material) have been developed by our laboratory. Silicone rubber combines the stability of the Silicones with the elastic properties of rubber. It has resistance to aging and retention of chemical and physical properties at temperatures far above and below the limits of rubbers.

Silicone is several times the price of rubber, but our Silicone Sponges, due to its light weight, is much cheaper than silicone solid rubber.

Silicone Sponges is, to some extent, a custom made product. We can compound this material to meet the customer's requirements, whether it be high tensile, low compression set, extremes of temperatures, etc. Our standard compounds are those which have the best balance of properties, including economy of production, and are considered general purpose stocks. It should be remembered that emphasizing one quality is usually at the expense of another.

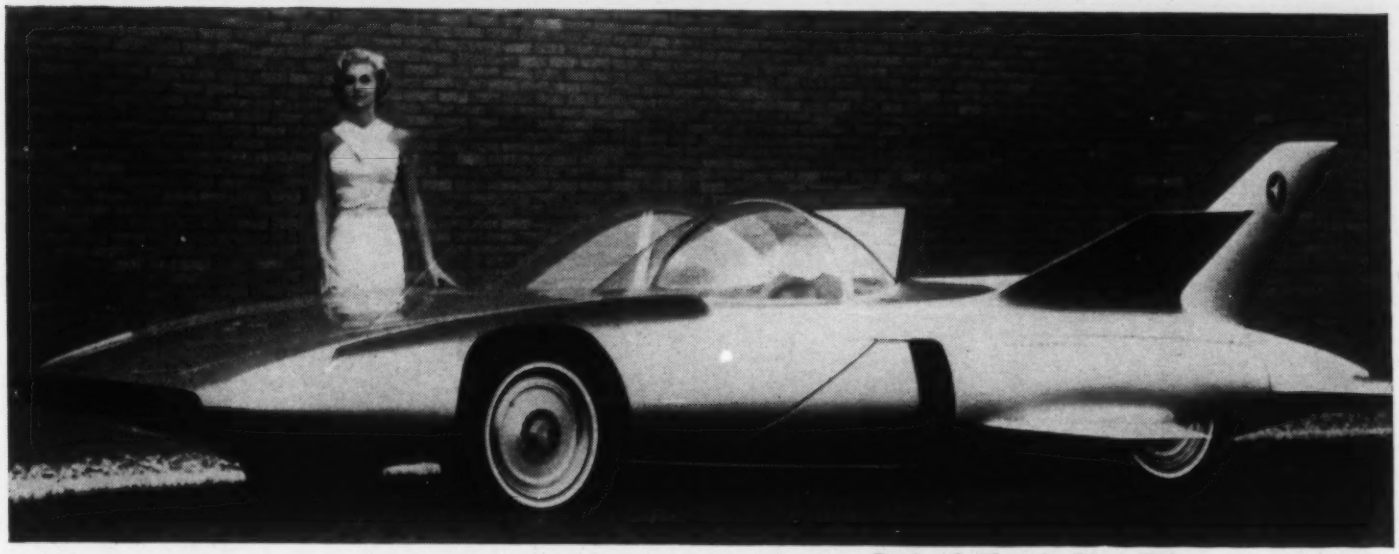




For this informative 26-page reference guide on cellular rubber, its properties and uses, write The B. F. Goodrich Company, 421 Derby Place, Shelton, Connecticut

B.F.Goodrich *industrial cellular materials*

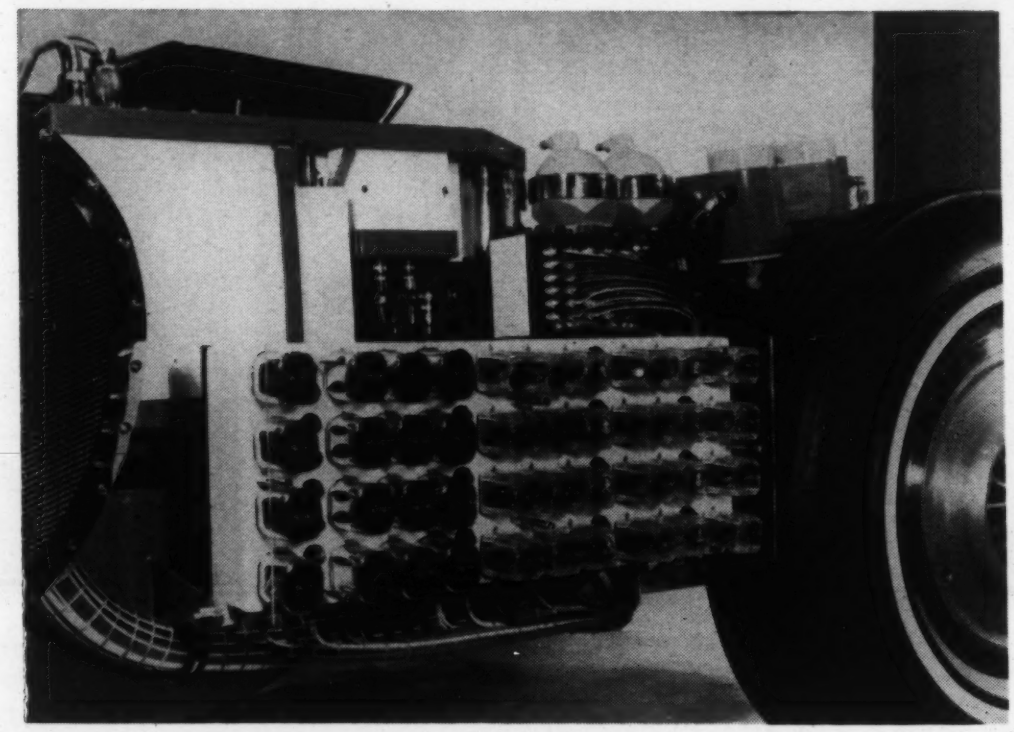
For more information, turn to Reader Service card, circle No. 442



Packard Electric Div., GM

MATERIALS AT WORK

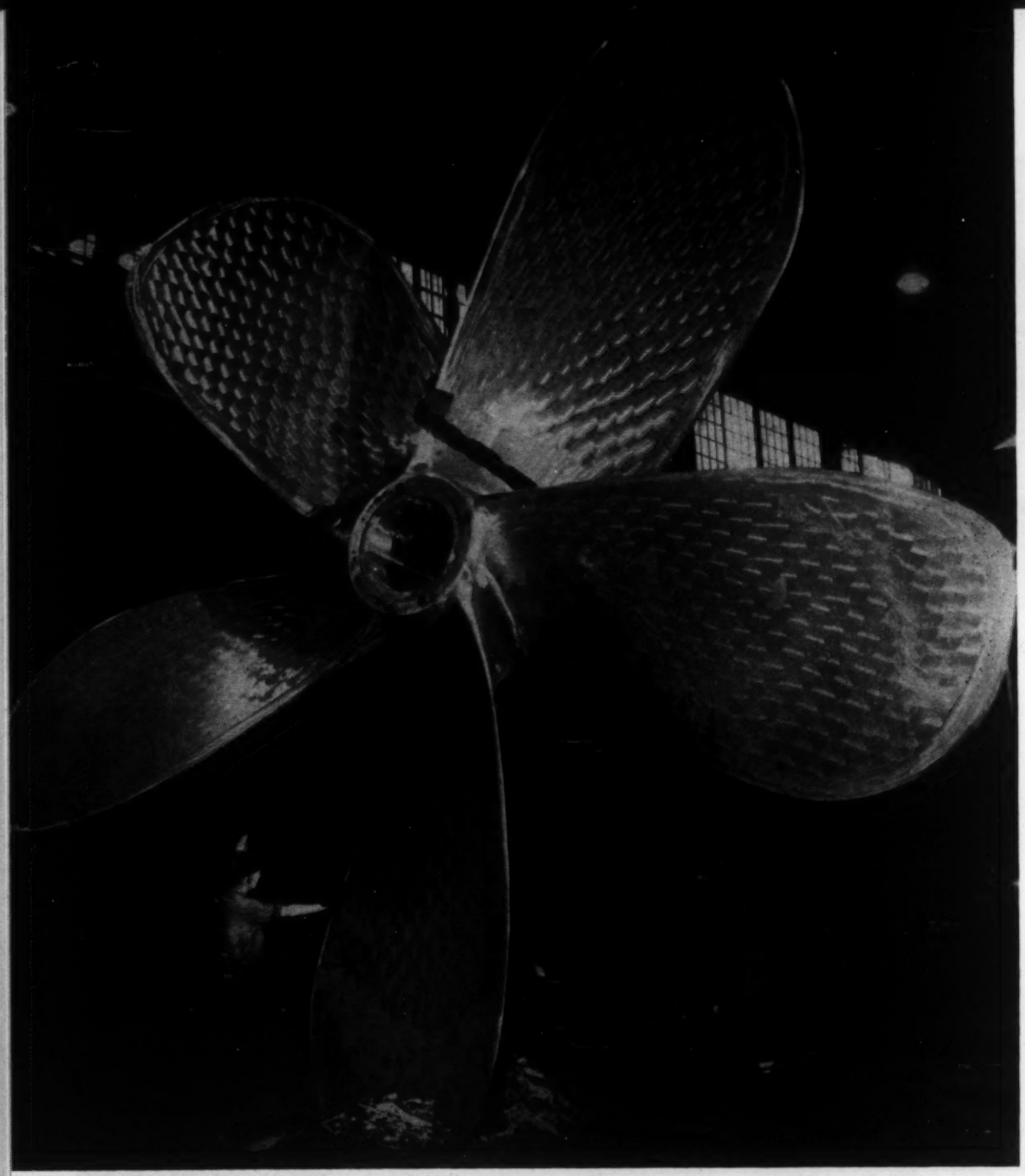
New and interesting applications of engineering materials



Firebird III uses light materials

The strictly experimental General Motors Firebird III shown above is probably the most advanced auto ever built, from both the stylistic and engineering design point of view. The car boasts such innovations as a "one-stick" control which acts as steering wheel, brake pedal and accelerator; electronically controlled automatic steering; dual engines, one of which is a gas turbine; air-oil suspension system; an anti-skid device that prevents wheel lock-up; electronic temperature control; special drag brakes that open like alligator claws to help slow the car at high speeds; fluorescent headlamps that turn on automatically when it gets dark; an ultrasonic "key" which opens the door and starts the car at a distance of 15 ft; and a two-way radio for communication between passengers and a control tower.

Some of the engineering materials used in the car include: glass-reinforced plastics body finished with a silver or gold acrylic lacquer; aluminum vapor-plated plastics canopies; molded plastics interior; 10-hp aluminum engine to drive accessories; cast aluminum combined wheel and brake drum; metal powder part brake linings; and two miles of Teflon-covered wire and cable which terminate in the electronic "nerve center" shown in the bottom photo.



MATERIALS AT WORK

Biggest propeller made

What is said to be the largest tank propeller ever made is shown in the photo at left. The gigantic manganese bronze sand casting weighs over 38 tons and measures 24 ft, 8 in. in dia. According to Eddystone Div., Baldwin-Lima-Hamilton Corp., the propeller will be used on the S. S. Apollo, whose launching is scheduled this month.

Largest machine part ever made of plastics

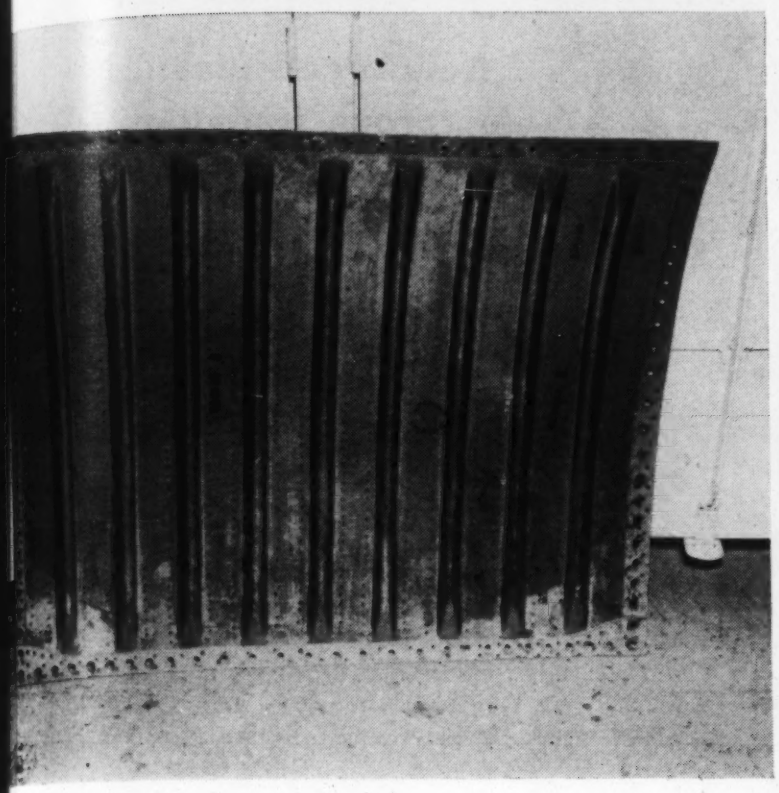
The auger shown in the photo at right may well be the largest machine part ever made entirely of plastics. Measuring 15 in. in dia and 50 in. long, it is used in a blender-feeder which mixes and transports viscous slurries in the production of chemicals. Use of the acrylic eliminates metal contamination.

In fabricating the auger, one major problem had to be overcome: the acrylic material was not available in sufficient thickness. The problem was solved by cutting 3-in. thick sheets of acrylic into disks, machine facing the flat surfaces of each disk, and cementing them together to make up the desired 50-in. length.

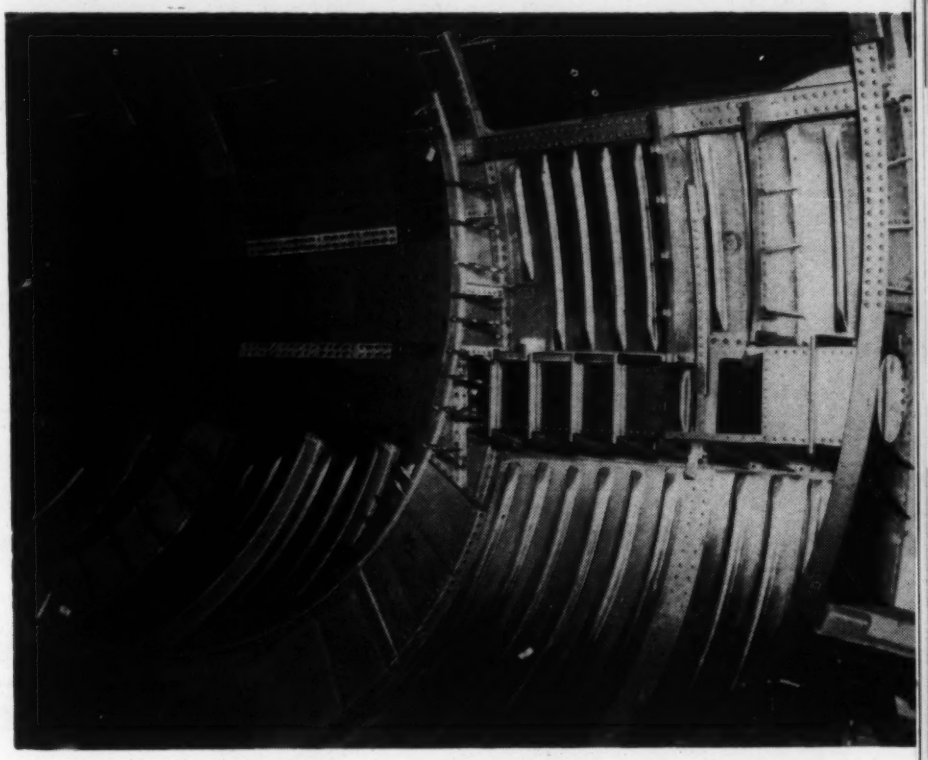
The large single cylinder of acrylic was then bored and keyed through its entire length for the insertion of a metal shaft, and the unit was turned on a milling machine.

Rohm & Haas Co.

Composite beaded titanium panels . . .



. . . are joined to form . . .



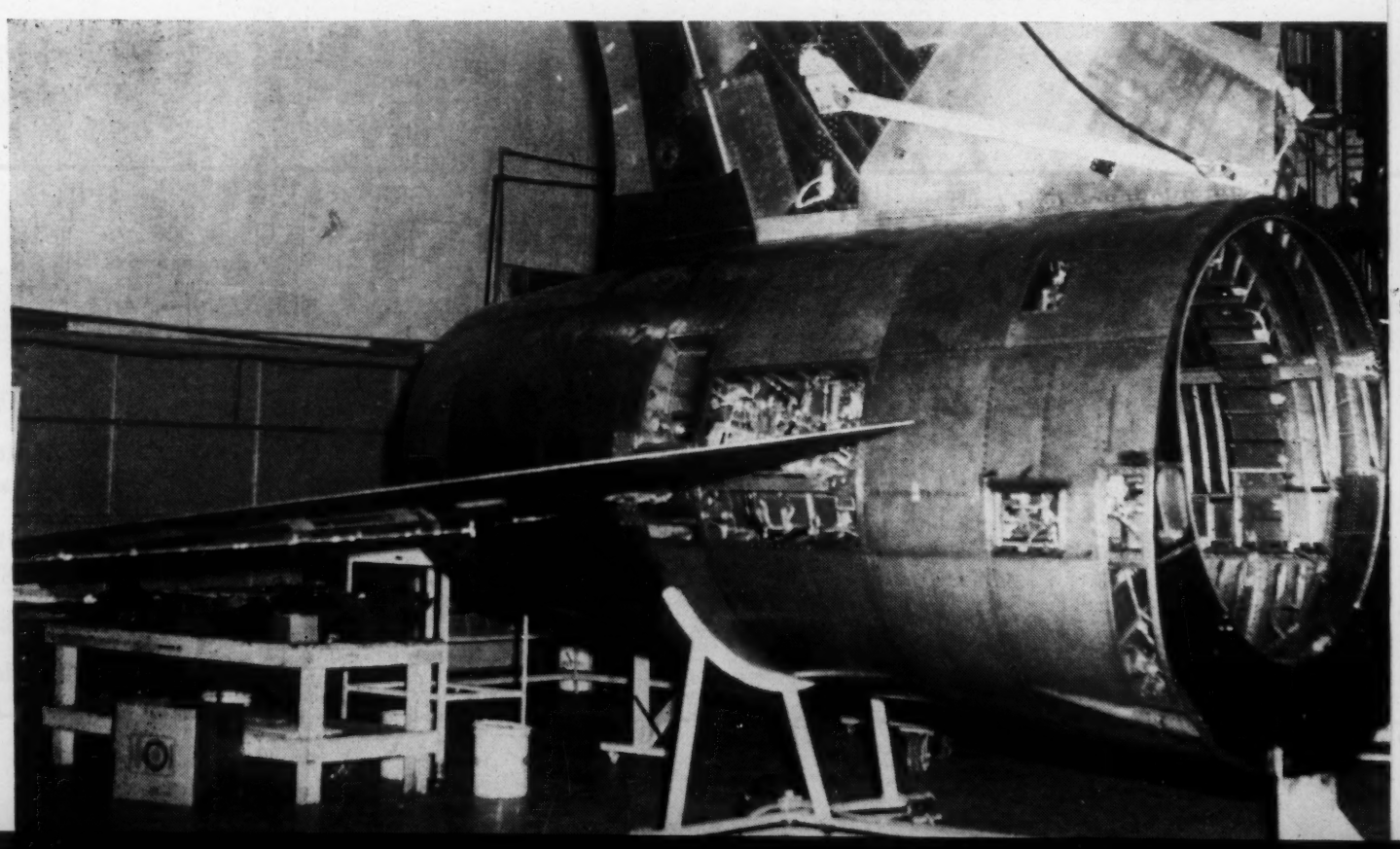
Spotwelded titanium cuts aircraft weight

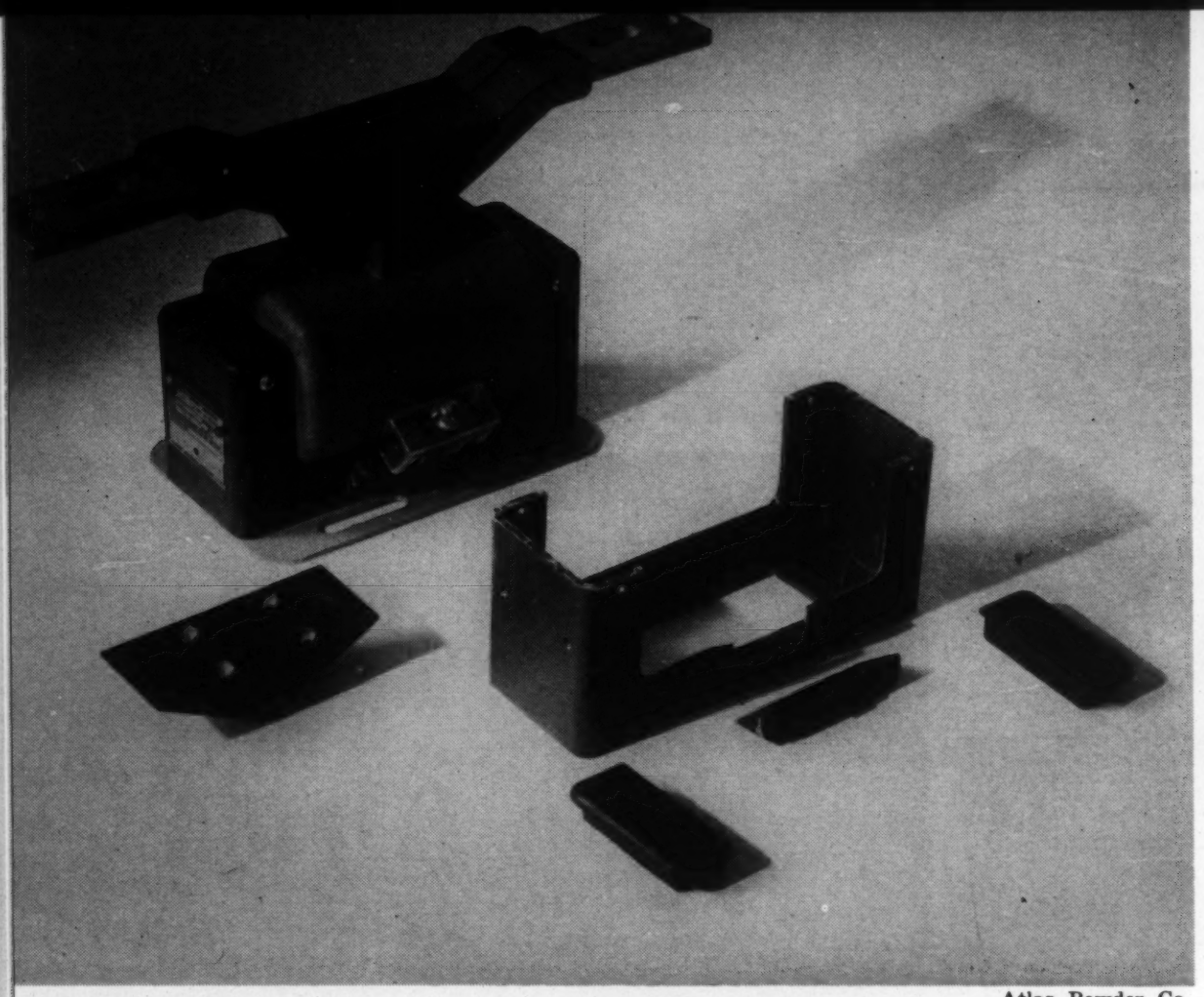
The use of spotwelded titanium sandwich panels for the skins of the aft section structure of the F8U-1 Crusader plane has resulted in considerable reductions in weight and manufacturing costs.

The aft section structure is composed of five bulkheads (to provide attachment points for the tail surfaces and for joining the aft section to the fuselage), five longerons and three keels. The composite titanium panels, composed of beaded pure titanium inner skins spotwelded to 8 Mn titanium alloy outer skins, are attached to the skeleton to complete the assembly.

According to Chance Vought Aircraft, Inc., the use of lightweight titanium structures has become feasible as a result of the relatively recent development of acceptable spotwelding techniques. In addition, Chance Vought is said to have developed a forming technique that eliminates the separate stress relieving operation: final forming and stress relieving are done in one operation by applying heat and pressure while stress forming the beaded skins.

. . . outer skin of aft section.





Atlas Powder Co.

Reinforced plastics improve transformer

The switch from hand-wound insulating tape and welded metal parts to a silicone-base insulating material and five molded glass-reinforced polyester parts has resulted in increased efficiency, improved appearance, and substantial reductions in assembly time, cost and weight for a new current transformer.

The reduction in weight and assembly time was achieved through the use of the five molded parts (see photo at left) which simply bolt together, thus eliminating the previous need for welding and strapping operations. The silicone insulation is molded directly to the coil assembly, thus eliminating the tedious operation of hand taping.

First section of aluminum bridge successfully tested

Use of aluminum in the construction of highway bridges has been given added impetus with the recent completion and successful testing of the first 50-ft section of the Fairchild Aluminum Bridge.

The test section, using the monocoque construction common in aircraft design, consists of three 50-ft long triangular beams of 0.081-gage rolled aluminum sheet stiffened by aluminum extrusions riveted to the sides of each sheet. The three triangular beams are connected edge to edge by bolts at the top to form a plate 24 ft wide (see photo below). A sheet of 0.125-gage aluminum forms the bottom plate. Aluminum alloy 6061-T6 is used throughout. A standard concrete roadway, joined to the bridge by shear ties, becomes a composite structural member of the bridge (see photo on p 190).

The vertical sides of the triangular beams form six canted webs which are the principal shear members. Extruded aluminum bulb angle stiffeners are riveted to the canted webs and bottom plate to insure the buckling integrity of the panels.

According to Fairchild Engine and Airplane Corp., main advantages of

(continued on p 190)

MORE MATERIALS AT WORK

Ceramic fixture for silver brazing 190

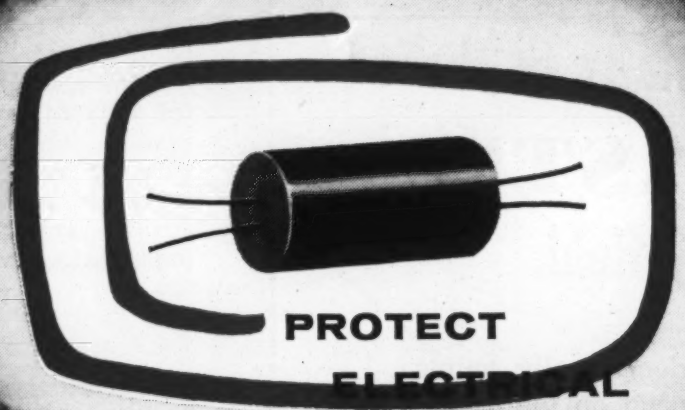
Teflon tubing, molding solve design problem 192

Largest dragline bucket 194

First all-welded aluminum tube dryer 196

CRITICAL COMPONENTS ENCASED IN

RCI EPOTUF RESINS



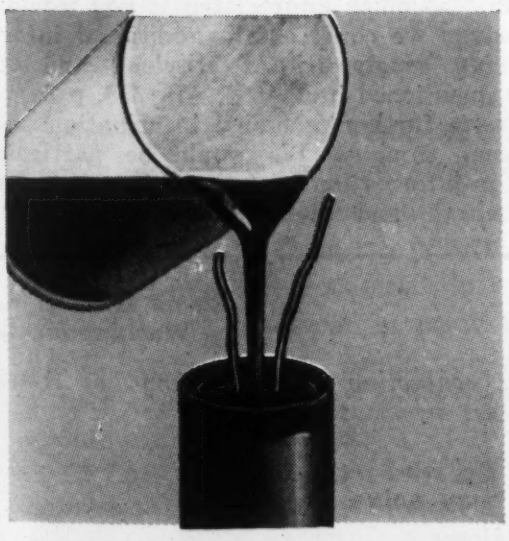
PROTECT

ELECTRICAL

APPARATUS

FROM INSULATION

BREAKDOWN



A long, trouble-free life is the forecast for electrical parts protected with RCI EPOTUF epoxy resins. Insulation made with these resins and appropriate hardeners is tough enough to surpass the most rigorous electrical and mechanical demands. Room temperature curing means no heat of reaction to harm delicate components.

Elements encapsulated, embedded or potted in EPOTUF epoxy resins are virtually free of failure, thus minimizing the need for costly maintenance and increasing the overall efficiency and reliability of the complete unit.

EPOTUF resins harden with outstanding adhesion to metals, glass, ceramics and other materials. They offer high mechanical strength and superior dielectric properties. The liquid nature of these resins permits penetration of fine crevices, and their low shrinkage assures highest dimensional stability.

If these numerous advantages of durable, dependable, corrosion-resistant EPOTUF epoxy resins fit your application, get in touch with RCI.

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
Hydrochloric Acid • Formaldehyde • Glycerine • Phthalic Anhydride
Maleic Anhydride • Sebacic Acid • Ortho-Phenylphenol • Sodium Sulfite
Pentaerythritol • Pentachlorophenol • Sodium Pentachlorophenate
Sulfuric Acid • Methanol

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- latches and handles
- pulls and knobs
- range and refrigerator hardware
- butts and hinges
- locks

NATIONAL LOCK COMPANY

ROCKFORD, ILLINOIS

PLASTICS DIVISION

For more information, turn to Reader Service card, circle No. 522

Letters to the Editor

Plastics in people

To the Editor:

We are interested in the availability of Teflon which can be foamed or which has already been foamed. Can you tell us whether or not such material is available and, if available, where it may be obtained?

We are also interested in the methods available for vacuum forming Teflon and sealing it to itself. Similar methods and forms which might be available for non-toxic silicone rubber are also a possibility for us.

We anticipate fabricating these materials for implantation within the body.

WILLIAM P. MURPHY JR., M. D.
President
Medical Development Corp.
Miami, Fla.

Teflon has not, as far as we know, been foamed. It can be heat sealed with difficulty and has not been vacuum formed to any extent. E. I. du Pont de Nemours & Co. might have further information. Information on silicone rubber for such critical application can best be obtained from such producers as: Dow Corning Corp., General Electric Co. and Union Carbide Corp.

Ethylene copolymers

To the Editor:

It would be much appreciated if you would tell us from whom we could obtain additional information covering copolymers of ethylene and other monomers, mentioned in M/DE, Aug '58, p 3.

We desire further technical information and if possible some samples. We would be particularly interested in information on temperature resistance, tensile strength, and the cost and availability of yarns.

JOS. L. GILLMAN, JR.
Joseph Gillman Asso.
Washington, D. C.

We advise contacting Celanese Corp. of America for the latest information.

Graphite may solve problem

To the Editor:

This is in answer to Mr. Sundling's letter, M/DE, Sept '58, inquiring about a material to support a glass picture tube during a sealing operation.

We have several carbon-graphite and electrographitic materials that are commonly used as guides of various forms in the glass industry. These materials have a low coefficient of friction and will not produce checks on the glass. Maximum temper-

"B&W extrusions

simplify our production problems

We can reduce final parts cost through the use of a B&W Extrusion because it cuts machining time and eliminates waste of costly material."

Machining is expensive and wastes material. It is doubly so when it is not necessary. Design engineers should investigate the possibility of using an extruded section as starting material, particularly if expensive or difficult to machine materials such as alloy or stainless steels are involved. In many cases, by using a B&W Extrusion, parts production can be reduced to a mere cutting to length and a few simple finishing operations.

To find out more about how B&W Extrusions can help you design a better product at a lower cost call on any of the local sales offices of B&W's Tubular Products Division or write for a copy of Bulletin TB 413. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

TA-8027-E1

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.

For more information, turn to Reader Service card, circle No. 432

at ADVANCE—

when engineers get together
die casting problems
get a real going-over

Here's a front gear cover for a motor vehicle engine designed by automotive engineers and ADVANCE die casting engineers working together.

Result: an efficient production die casting that brought cost reduction to the engine builder and produced a better engine for the vehicle operator.

ADVANCE experience in solving manufacturing problems before those problems arise may be helpful to you, too, for many of your component parts.

Send your drawings to ADVANCE for a "Problem Survey" and production cost estimate.

These symbols are your assurance of highest quality control of zinc and aluminum alloys under ADCI standards.

38 years of service to industry.

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3770 N. Holton Street
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For more information, turn to Reader Service card, circle No. 463

atures of 360 F will have no effect on the coefficient of friction or other properties of our materials.

Specific recommendations can be made from a print of the supporting ring if the load on the ring and the speed at which the funnel rotates are known.

B. SILVER
Chief Engineer
Electro-Nite Carbon Co.
Philadelphia, Pa.

Tungsten carbide tools

To the Editor:

Please send addresses where I may purchase tungsten carbide blanks.

Do you have instructions for cementing these blanks to make long-life turning tools?

GRANVILLE STRUNK
Lafayette, Calif.

A list of suppliers who should be able to help has been forwarded.

Cold extrusion of steel

To the Editor:

We take exception to your reply to Mr. Arthur M. Shrager's letter in the September issue. You stated that you were aware of only one custom producer of cold extrusions from steel. We would like to call to your attention the fact that we have commercially participated in this field for well over two years.

The magnitude of our success is indicated by one particular piece—a critical automobile front suspension part. We produced several million sets of these without a field failure.

JACK S. SMITH
Imerman Screw Products Co.
Detroit, Mich.

We welcome the opportunity to bring this company to the attention of our readers.

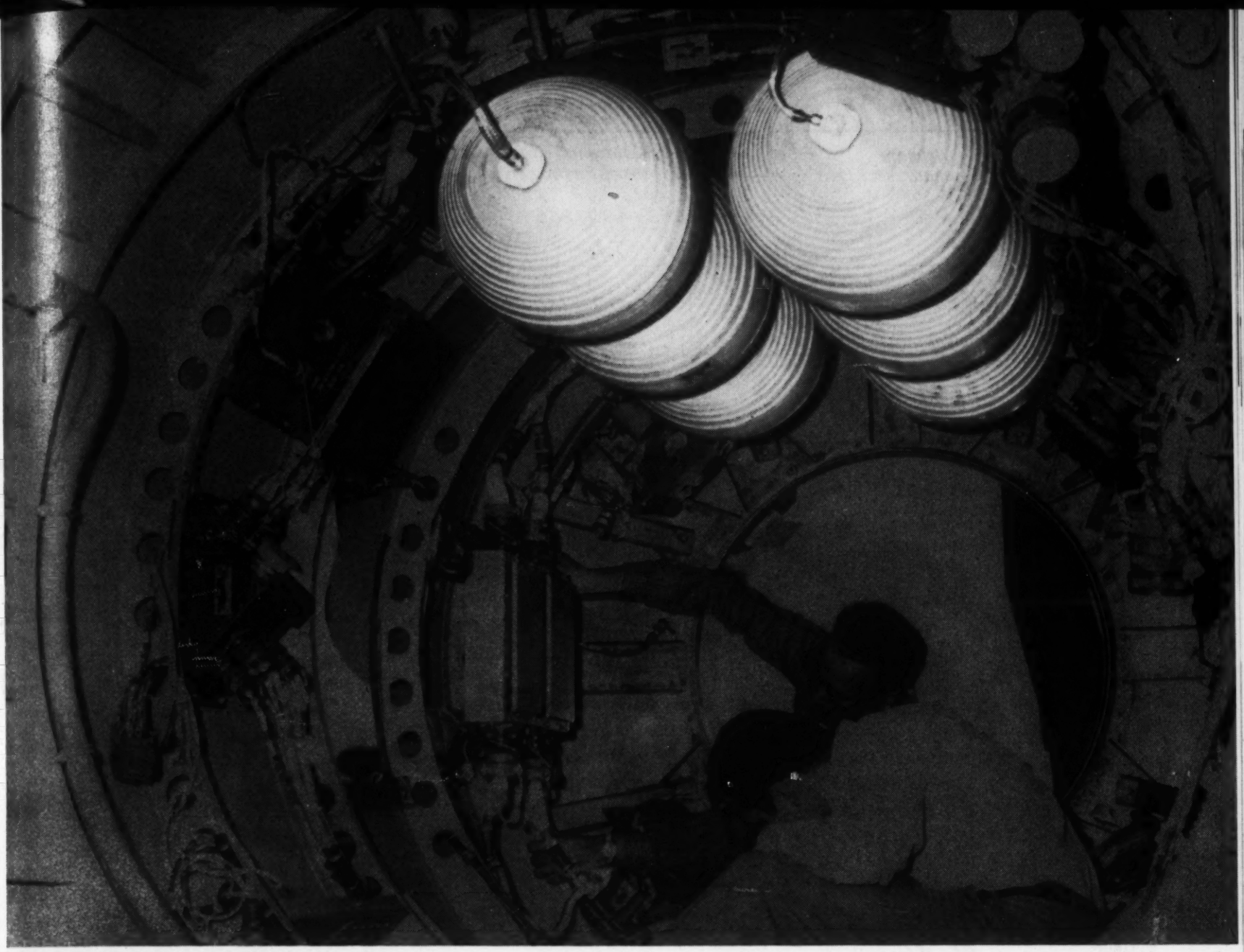
Composition board

To the Editor:

I am preparing a book on the applications of phenolic resins. In this connection, do you have any up-to-date information on the production of particle board and hardboard?

DAVID F. GOULD
Burlington, N.J.

We suggest contacting Forest Products Laboratory.



Redstone ballistic missile *uses plastics pressure vessels. Here six are shown in manifolded position in tail section.*

Now you can specify

Plastics Pressure Vessels

by **Arthur J. Wiltshire,** *Chief Engineer, Apex Reinforced Plastics Div., White Sewing Machine Corp.*

Here is an up-to-date report on . . .

- *Common types and materials*
- *How to design them*
- *How they compare with metal vessels*
- *Where they are used*

■ Developments in fabrication techniques and materials technology have, to a great extent, overcome the early limitations of reinforced plastics for use in pressure vessels (see Plastics Pressure Vessels, MATERIALS & METHODS, Oct '55, p 107). The major benefits of plastics as the structural material for pressure vessels—light weight, shatter resistance, corrosion resistance and lack of notch sensitivity—have led to many applications of such vessels in military aircraft and missiles, and indicate a promising future for civilian use.

Common types and materials

Most plastics pressure vessels successfully used today are spherical, and the discussion here is limited to such vessels. The most popular types for military use are designed for 3000 psi operating pressure over a service life of either 10,000 or 1 million cycles (from zero to full operating pressure and back to zero), and for a service temperature range of −65 to 200 F. Such bottles have a 5000-psi proof pressure and a 7500-psi minimum bursting strength, though applicable military specifications call for a minimum burst

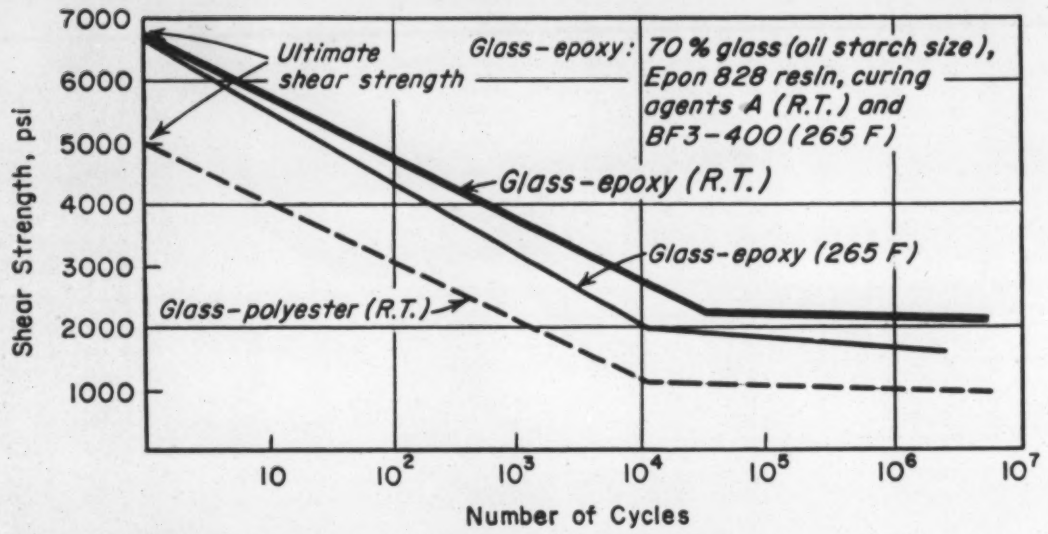

Shear Strength, psi
Number of Cycles
Ultimate shear strength
Glass-epoxy: 70 % glass (oil starch size), Epon 828 resin, curing agents A (R.T.) and BF3-400 (265 F)
Glass-epoxy (R.T.)
Glass-epoxy (265 F)
Glass-polyester (R.T.)

***Fig 1**—Effect of fatigue on reinforced plastics is shown by these S-N curves. Glass-epoxy room temperature curve is used for design of vessels.*

of only 6667 psi.

The materials combination found by Apex to be most effective is a continuous-filament glass fiber-reinforced epoxy resin with an SBR (styrene-butadiene) rubber lining. Thickness of the liner usually ranges from 3/32 to 1/8 in. depending on service needs.

Epoxy resins provide maximum strength in the binder. In the laminates, as can be seen in Fig 1 above, epoxies provide both a higher ultimate shear strength and higher endurance limits than do polyester resins. Epoxies also provide a high degree of chemical stability. Finally, their strong adhesion to the glass fiber is responsible for the lack of fragmentation that occurs when the vessel is ruptured by gunfire.

Key to the high strength and reproducibility of quality in the plastics laminate is the filament winding process. The process provides laminates of maximum strength by applying the glass fibers to the sphere in such a way that when the sphere is pressurized the fibers are stressed primarily in tension. Since the process is mechanized, the fibers are applied in the same predetermined orientation from bottle to bottle.

The —65 to 200 F service temperature limits on the bottles are primarily established by the limitations of SBR rubber. A rubber with broader temperature limits could extend the service temperature range of such bottles. Though temperatures as high as 265 F lower the fatigue strength of epoxy-glass laminates (see Fig 1), bottles could be designed for higher temperature operation by making use of lower design stress values.

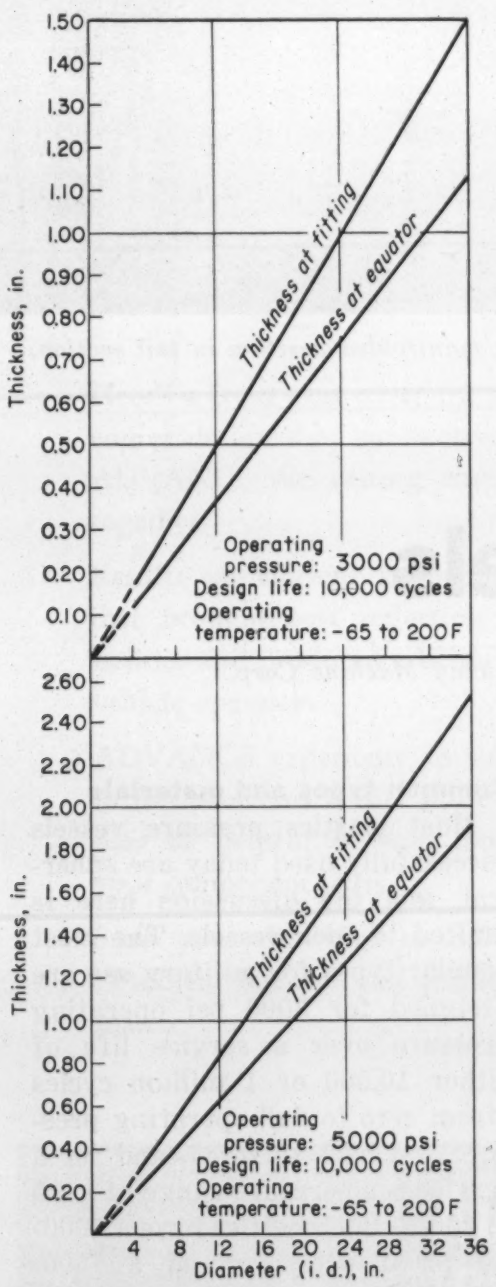

Thickness, in.
Diameter (i. d.), in.
Thickness at fitting
Thickness at equator
Operating pressure: 3000 psi
Design life: 10,000 cycles
Operating temperature: -65 to 200 F
Operating pressure: 5000 psi
Design life: 10,000 cycles
Operating temperature: -65 to 200 F

***Fig 2**—Thickness vs diameter for plastics bottles designed for 3000 and 5000-psi operating pressures.*

Design of plastics pressure bottles

The equation used in the design of spherical pressure vessels is:

$$S = \frac{PD}{4t}$$

where:

S = max allowable design stress of the material, psi
P = min bursting pressure, psi
D = diameter of the vessel, in.
t = mean thickness of the wall, in.

Since the diameter of a pressure bottle is primarily established by service requirements, the required thickness can be determined when maximum allowable design stress and minimum bursting pressure are known.

Maximum allowable design stress —Glass fiber-reinforced plastics do not have a yield point or elastic limit as do most metals; thus, allowable design stresses must be

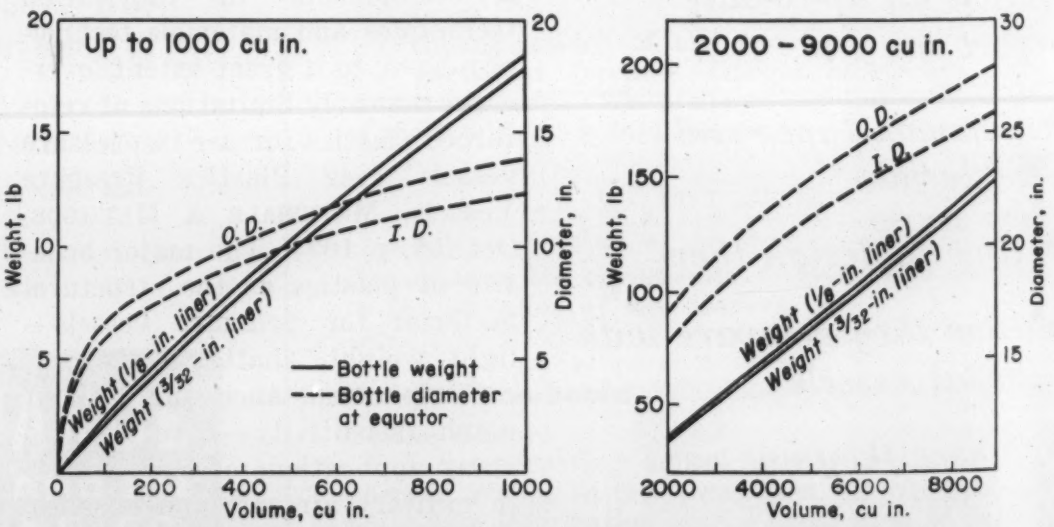


***Fig 3**—Diameter and weight vs volume for plastics bottles designed for 3000-psi operating pressure and 10,000-cycle life.*

selected at relatively low percentages of ultimate strength to obtain satisfactory life in a cycled pressure vessel.

Ultimate tensile strength of "fish-pole" stock (unidirectional fiber reinforcement) of the glass-epoxy system used in plastics pressure vessels is about 145,000 psi. Tensile tests at Apex have confirmed the theory that as a result of the multidirectional orientation of the fibers in a spherical pressure vessel, the ultimate tensile strength of a sample taken from a vessel wall is approximately one-half that of fish-pole stock, or 70,000 psi.

Since most pressure vessels are cycled in service, the effects of fatigue on ultimate strength must be considered in design. The S-N curves in Fig 1 are used to determine the magnitude of the effect of fatigue on strength. For example, for so-called single shot pressure bottles (used in rockets), designed for a fatigue life of 1000 cycles, shear strength of the laminate at the 1000-cycle fatigue level — as determined from the S-N curves—is about 54% of ultimate strength. In designing such bottles, a value of 54% of the ultimate strength value of 70,000 psi, or 37,800 psi, is used as the maximum allowable design stress.

Where the design life of the bottle is to be 10,000 or 1 million cycles, lower values of 40 or 25%, respectively, are picked off the S-N curve and applied to the ultimate tensile strength value to obtain maximum allowable design stress.

Minimum bursting pressure—The minimum burst pressure value to be used in the design of a given vessel is determined from the desired operating pressure by applying a safety factor. The magnitude of the safety factor to be used in the design of a given vessel is based on the magnitude of the effect of fatigue on strength of the material at the required service life of the vessel, as determined by the S-N curve. For 10,000-cycle-life bottles, minimum burst values are mathematically determined by establishing the desired operating pressure at 40% of minimum burst; for 1 million cycle life, operating pressure is established at 25% of minimum burst.

No fragmentation *occurs when plastics bottles are burst.*

Design curves—Fig 2 shows graphically the relationship between laminate thickness and diameter for bottles designed for 3000 and 5000-psi operating pressures, 10,000 cycle life and a service temperature range of—65 to 200 F. Note that two curves are given, representing thickness of the laminate at the fitting area and the equator, respectively. Walls are thicker at the area around the fitting to compensate for the unsupported hole.

Fig 3 shows the relationship between bottle diameter and volume, as well as bottle weight in relationship to volume, for bottles designed for 3000-psi operating pressure, 10,000-cycle life, and —65 to 200 F operating temperature.

How plastics compare with metals

General comparisons between reinforced plastics and metals as pressure vessel materials are difficult (and sometimes misleading) because of the many variables to be considered in the design of any one pressure vessel. Some general comparisons can be made, however, which help to put plastics in clearer perspective as an unfired pressure vessel material.

The accompanying data compare spherical, filament-wound glass-reinforced epoxy pressure bottles with 1) theoretical design calculations for welded spherical bottles fabricated of SB-178 GR-40A (A54S), the strongest aluminum alloy accepted by the ASME Boiler and Pressure Vessel Code (Case No. 1174) for

Where They're Used

Since the first plastics pressure vessel was developed for air fuel starter systems on jet aircraft, Apex alone has produced more than 10,000 bottles of varying sizes, most of them for military applications. They are used for: storage of compressed gases for jet starting systems; fuel tank purging units; actuation of such emergency equipment as aircraft seat ejection; ground starting equipment for large jet bombers; launching torpedoes from surface ships; and many other uses which are classified.

Although most work has been done for the military, Standard Oil of New Jersey is now using such bottles for collecting high pressure hydrocarbon gases in oil refineries. Other future civilian applications which seem promising include: tanks for pneumatic brake systems in aircraft; aqualungs for diving equipment; and l-p gas tanks on house trailers.

welded pressure vessels (see MATERIALS & METHODS, Apr '54, p 97), and 2) an alloy steel actually used to fabricate a welded spherical bottle.

The design stress used in the aluminum bottle calculations is the conservative value of 7350 psi, called out as maximum allowable design stress by the Code. For welded unfired pressure vessels, the alloy must be in the "O" or annealed condition, since welding temperatures would tend to anneal and thus weaken areas around the weld.

The design stress of 30,500 psi for the steel calculations is minimum bursting stress as calculated from a sample bottle designed for 3000 psi operating pressure. Since this design stress is much higher than any allowed for welded vessels by the ASME Code, the comparisons of plastics with steel are conservative.

Design stress used in the glass-epoxy bottle calculations is 28,000 psi, or 40% of the 70,000-psi ultimate strength (determined from the S-N curves at the 10,000 cycle fatigue point).

Weight—Fig 4 compares weight vs volume for aluminum, steel and plastics bottles designed for 3000 psi operating pressure. Reliability of the curves seems to be borne out by the comparison of an actual steel bottle, obtained from a metal fabricator, with one of reinforced plastics. Both were 12-in. i.d. bottles designed for the same life and use. The steel bottle weighed 32 lb as compared with 16.5 for the plastic. These comparisons should not be considered as definitive, as other fabricators using a different production process could possibly produce a lighter metal bottle.

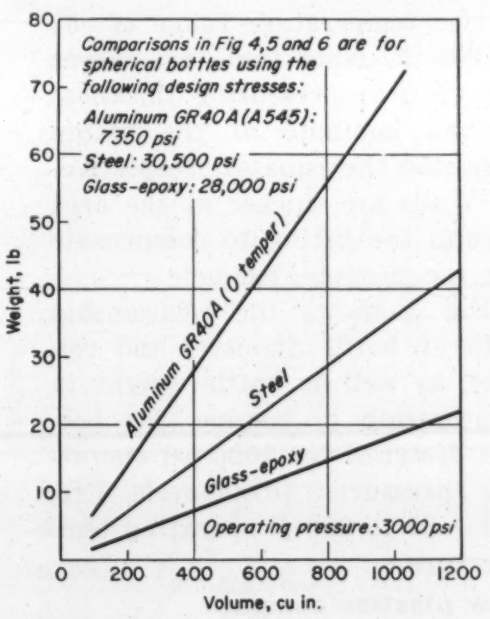


Fig 4—*Weight-volume comparison of aluminum, steel and plastics.*

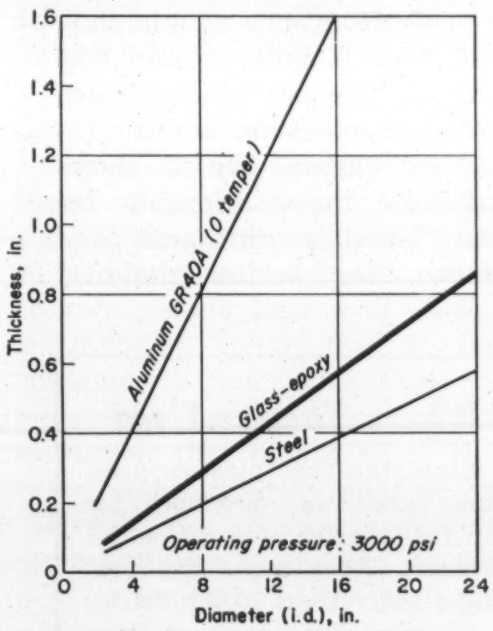
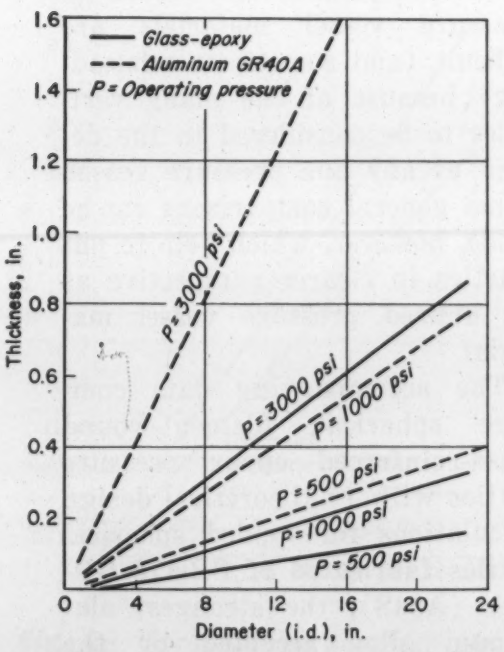


Fig 5—*Thickness-diameter comparison of aluminum, steel and plastics.*



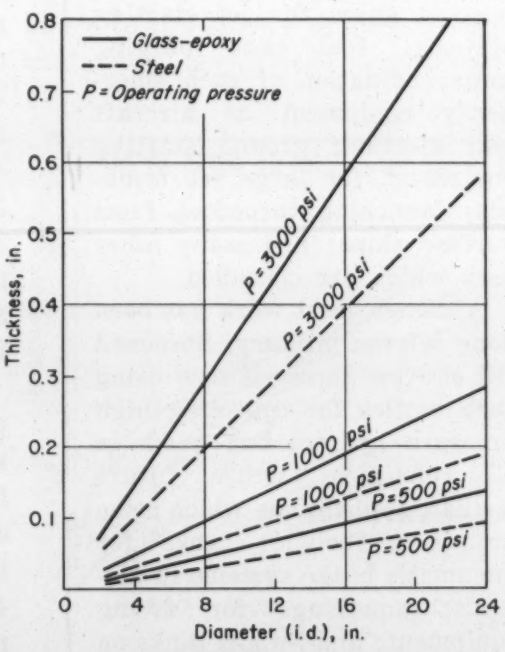


Fig 6—*Thickness-diameter comparisons of aluminum and plastics (left) and plastics (right) bottles at various operating pressures.*

Wall thickness—Fig 5 compares wall thickness vs diameter of steel, aluminum and plastics bottles designed for 3000 psi operating pressure. For the same diameter the plastics bottle must have a thicker wall than the steel bottle, but this increase in material is more than offset by the lower specific gravity (about 1.8, depending on glass-resin ratio) of the reinforced plastic.

Fig 6 compares thickness vs diameter of plastics and aluminum bottles, and plastics and steel bottles, at operating pressures of 3000, 1000 and 500 psi.

Other benefits—From the military standpoint, one of the most important advantages of the material as opposed to metal is its resistance to shattering on impact of gunfire. Gunfire tests on the bottles show no tear qualities or shattering in the laminate.

Reinforced plastics vessels have a degree of corrosion resistance superior to any of the conventional pressure vessel metals, even aluminum.

Although filament-wound reinforced plastics are not impermeable to gases, the SBR rubber liner provides extremely low leakage rates. The following rates have been determined for such bottles (volume is expressed in cu in. at 3000 psi; leakage rate in lb per week):

Volume	Leakage Rate	
	Air	Helium
870	0.05	0.10
1300	0.064	0.128
1770	0.10	0.20
2570	0.15	0.30
5380	0.30	0.60

Extensive tests have indicated that creep in filament-wound bottles is negligible. During cycling from 0 to 3000 operating pressures, the i.d. of the bottles changes 0.0075 in. per in., but no permanent deformation takes place.

Heavy duty axle shafts *are typical rotary forgings.*

Three New Ways to Make Precision Forgings, Extrusions

by John F. Murphy, *Chief Production Engineer, Metal Processing Div., Curtiss-Wright Corp.*

■ Several new methods of chipless fabrication have been developed to meet the need for high strength in aircraft engine components and economy in the use of material, particularly important in working with high cost materials. The three methods are: 1) rotary press forging, 2) a precision gear forging, and 3) cross extrusion. The latter two methods are still in the development stage in the United States.

1. Rotary forging

Rotary forging is one of the newest developments in precision forging. A part is formed by rotating a workpiece vertically in the machine and hammering it with four hammers operating horizontally. The process may be thought of as a lathe operation in which the cutting tool is replaced by hammers. The shape is controlled either by forming the desired contour in the hammer face or by controlling the length of the hammer stroke.

An exploded view of the machine is shown in an accompany-

TYPICAL SAVINGS ACHIEVED BY ROTARY FORGING—

COST

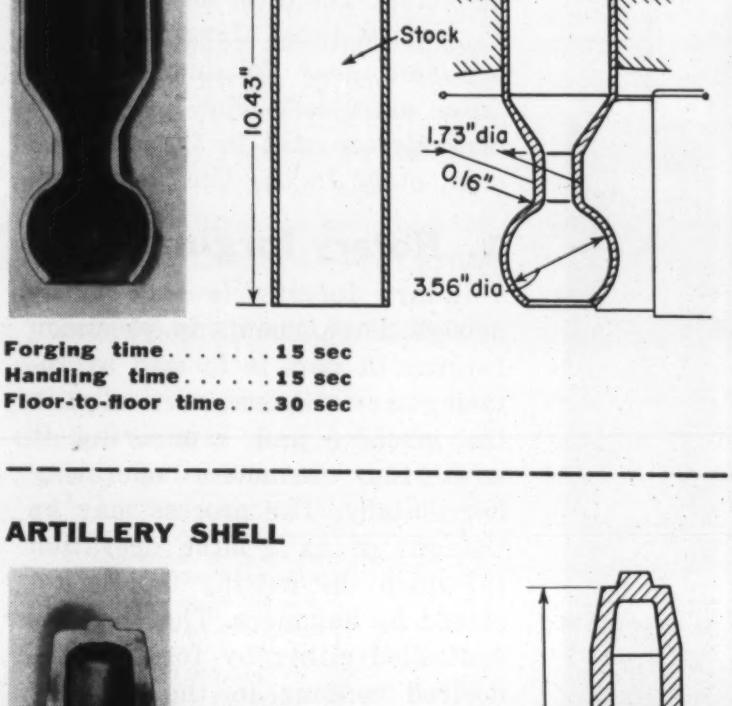
	Rough Forging	Rotary Forging
Forging Cost, $	10.75	10.00
Machining Cost, $	16.10	10.79
Total Cost, $	26.85	20.79
Weight, lb	34	20

WEIGHT

Part	Steel	Weight, lb		Reduction in Weight, %
		Rough Forging	Rotary Forging	
Truck Axle	4150	53	35	34
Tool Joint	4142	57	34	40
Turbine Shaft	431	12	9.5	21
Tractor Shaft	4142	52	31	40
Spline Shaft	4142	87	54	38
Generator Shaft	4130	12	5.5	54

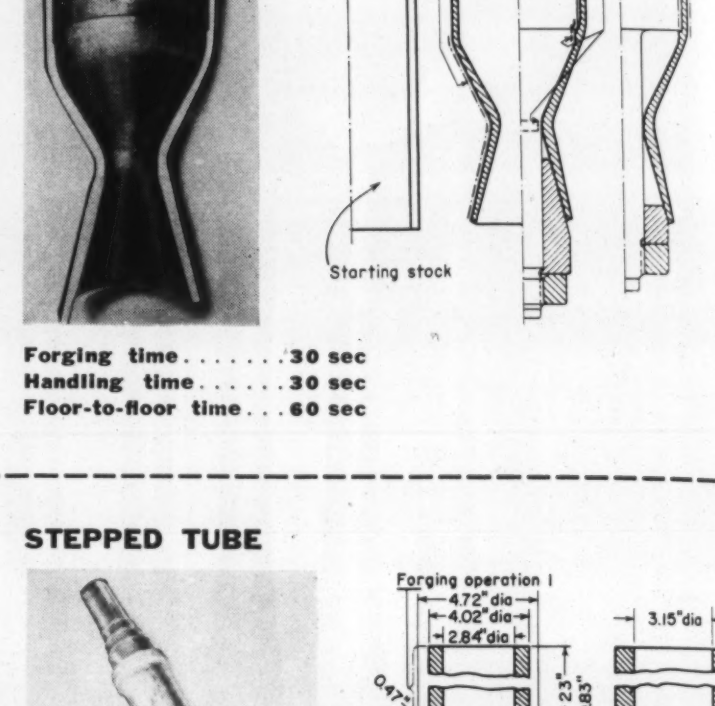
These parts were produced by rotary forging

BALL-END TUBE



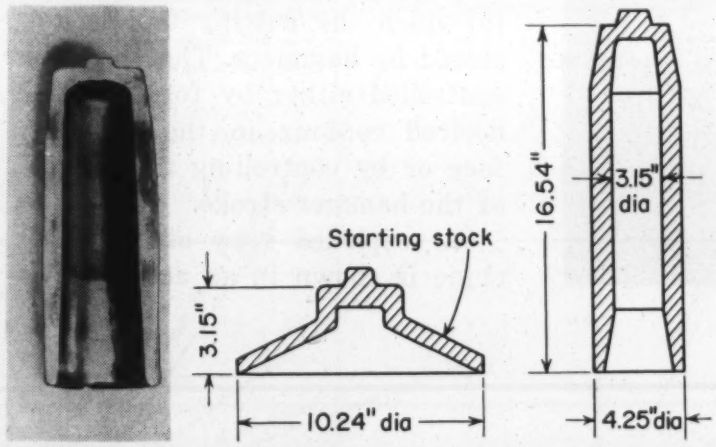
Forging time . . . . . 15 sec
Handling time . . . . . 15 sec
Floor-to-floor time . . . 30 sec

VENTURI TUBE



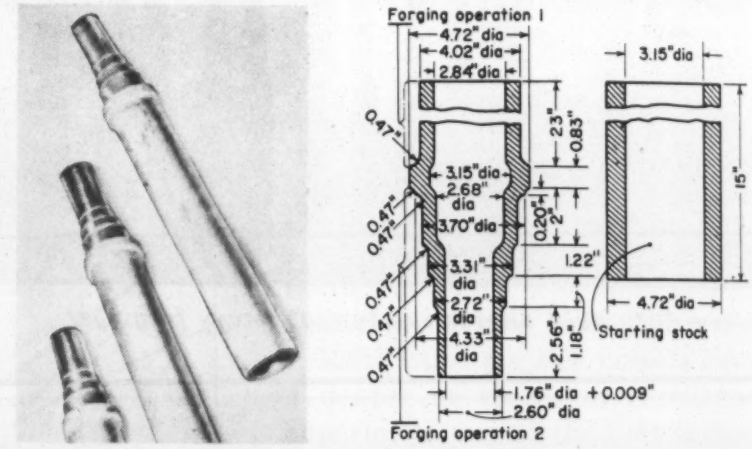
Forging time . . . . . 30 sec
Handling time . . . . . 30 sec
Floor-to-floor time . . . 60 sec

ARTILLERY SHELL

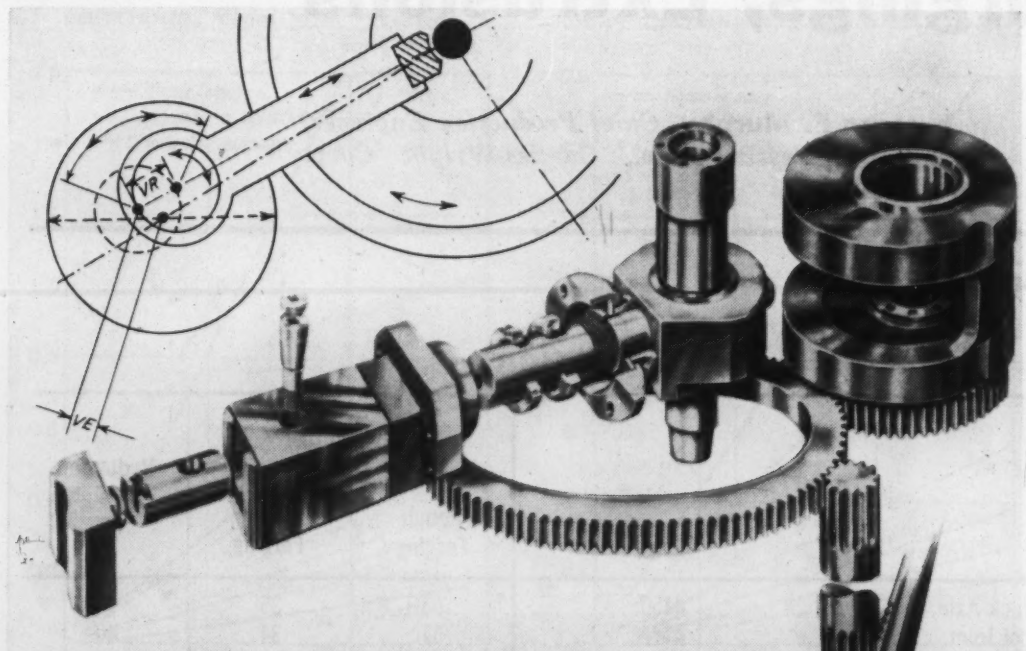


Forging time . . . . . 25 sec
Handling time . . . . . 25 sec
Floor-to-floor time . . . 50 sec

STEPPED TUBE



Forging time (short end) . . 30 sec (long end) . . 40 sec
Handling time (short end) . 15 sec (long end) . . 15 sec
Floor-to-floor time (for both operations) . . . . . 100 sec



Rotary forging hammer *and eccentric assembly (in exploded view) show how throw of hammer can be programmed to fit contour desired in the part.*

ing sketch. The hammer throw can be programmed to fit the contour desired in the forged part as the workpiece is lowered automatically past the hammers. Hollow parts are formed by forging against a shaped mandrel. Intricate shapes can be formed to close tolerances by this procedure.

The rotary forging machine can take solid parts up to 4 in. in dia and hollow parts to 5 in. in dia, with lengths up to 39 in. Tolerances obtainable are:

Hot working: o.d. ±0.012 in., i.d. ±0.004 in.
Cold working: o.d. ±0.004 in., i.d. ±0.0004 in.

Hot working refers to operations at the normal forging temperatures for the material and is used when maximum movement

of stock is desired. Scale-free heating is necessary to obtain the surface finish and tolerances required. Cold working refers to room temperature forging and is used to obtain a high precision internal contour.

Normally a greater amount of working occurs in this process than in conventional forging, and this working improves strength and gives more uniform grain flow.

Applications — Rotary forging has been used to produce heavy duty axle shafts, venturi tubes, ball end tubes, artillery shell, splines, gears and rifled gun barrels.

Cost and weight savings for typical forgings are indicated in the accompanying tables which compare rough forging with rotary forging.

2. Precision forging of gears

Precision forged gears are currently produced in Germany by a modification of conventional hot forging using a screw press instead of a crank press. The action on the metal is roughly halfway between that of a crank press and a drop hammer; a little more impact than with the crank press, a little less than with the drop hammer. Economical operation results from designing the dies to permit rapid changing.

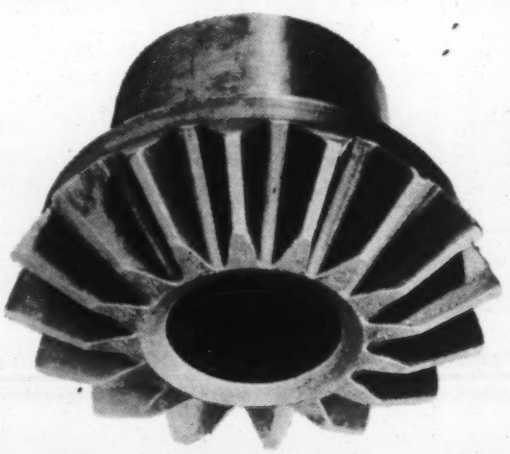
Design of bolster plates and die holding mechanisms for maximum rigidity and strength permits production of gears with tolerances sufficiently close for most uses without additional machining on the teeth. Minimum tolerances of 0.0015 in. on tooth profiles, tooth spacing and pitch diameter are obtainable. Only the teeth and the faces of gears are precision forged; the hole and back face of the gear are machined.

Comparison of the tooth strength of gears produced by precision forging with that obtained on conventionally cut gears shows substantial increases for the forged gears. Increased strength is attributed to the preferential grain flow around each tooth.

Carburizing grades of steel have been used most widely in the production of parts, mainly gears, by this process. Tool steels have been used in the production of machine tools. Stainless steels have been used for some parts.

Applications — This precision forging process cannot compete with hobbing operations in which stacks of gears are loaded into machines and one operator operates several machines. However, savings up to 25% can be obtained in forging aircraft gears that require a sequence of operations, and the process is particularly attractive for producing parts from high cost materials such as the high temperature alloys or titanium.

Up to the present time, the major production items have been straight and spiral bevel gears, differential side gears and pinions, ring gears and spur gears. Sizes range from 1-in. dia pinions to 8-in. dia hypoid ring gears. Small cogs, ratchets, cams and milling cutters have also been produced.



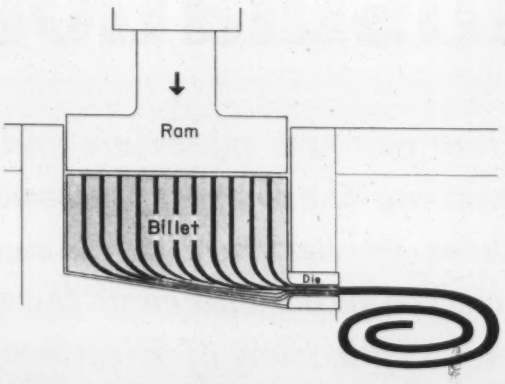
Differential side gear *can be precision forged by German process to tolerances sufficiently close for many applications without machining the teeth.*

3. Cross extrusion

Cross-extruded sections are produced by hot extruding through a die set at an angle of 90 deg to the direction of applied force. The objective is to produce the maximum internal working on the material and to equalize more nearly than usual the longitudinal and transverse properties. A sketch of the operation is given on this page. Although the procedure is still in the development stage, properties obtained indicate that cross extrusion will find a definite place in future metalworking operations.

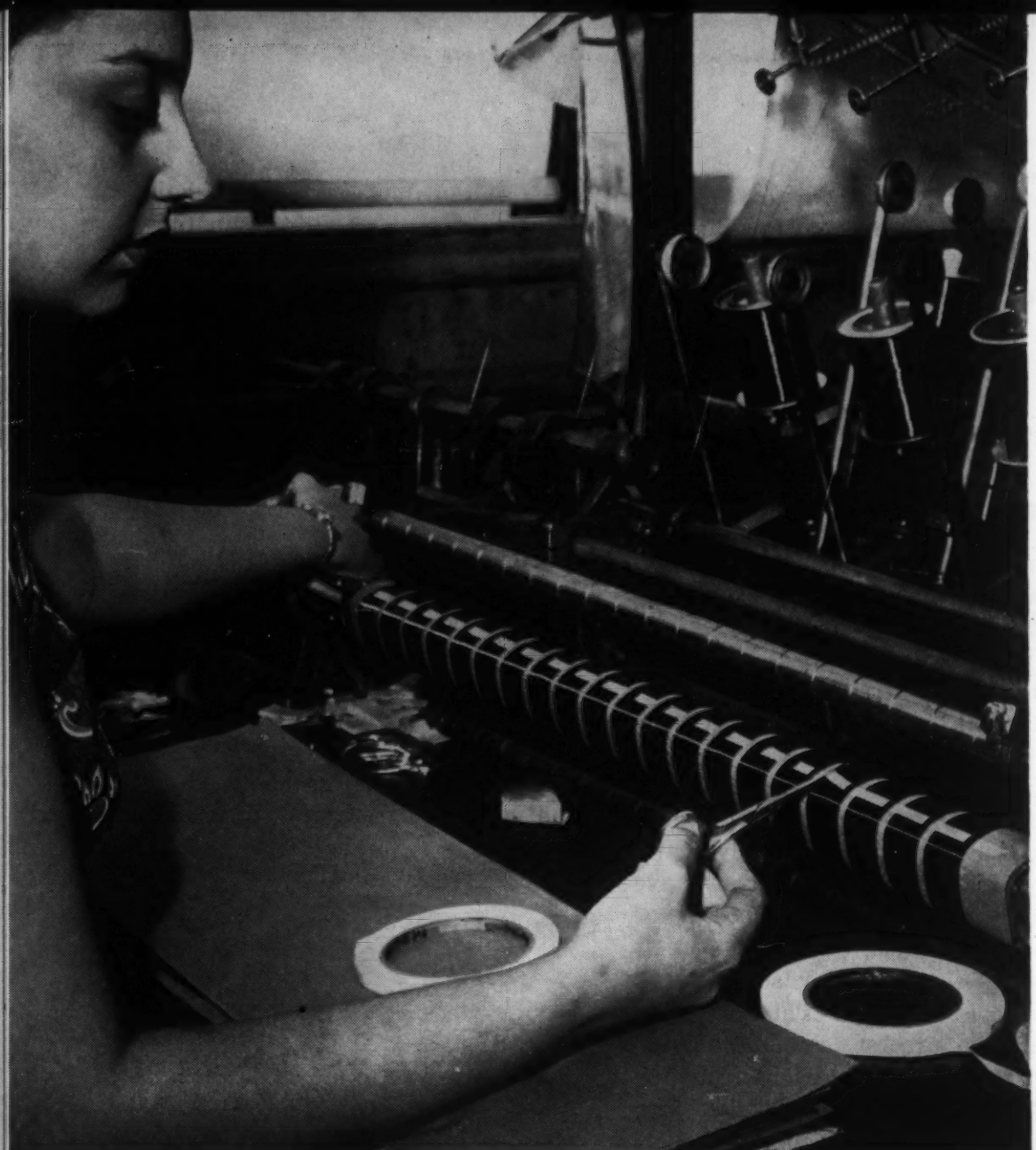
Cross extrusion has been used to produce SAE 6150 steel wire 0.410 in. in dia with surface finish about the same as that required by standards for hot rolled wire. Tolerances were ±0.007 in. on the diameter and ovality within 0.015 in. Other materials that have been investigated are stainless steels, high speed tool steels, copper alloys, aluminum and titanium.

Applications — The process will be particularly applicable to the production of quantities of material too small to justify rolling. It can also be used to produce an extrusion from a cast billet with properties equivalent to those obtained from a forged or rolled section. The process is not intended to compete with normal rolling but to produce a high quality specialty material in special sizes and shapes.



Cross extrusion *is illustrated schematically here. Die and ram are set at 90 deg to each other.*

This article is adapted from a paper given at the Society of Automotive Engineers National Production Meeting and Forum, Mar '58.



Permacel-Lepage's, Inc.

Precured electrical tape *simplifies production since it does not require time-consuming curing at elevated temperatures.*

What's New in

Electrical Insulation

Here are new materials and other developments aimed at meeting the increasing capacity and operating temperatures of electrical equipment. This report is based on selected papers given at the recent National Conference on the Application of Electrical Insulation.

Data on laminates at high temperatures

Experience has shown that plastics laminates are extremely desirable as insulating materials because of their unusual combination of properties. A good deal of information has been published on these properties (see M/DE, Feb '57, pp 121-140); however, data on the characteristics of laminates at temperatures over 400 F have been difficult to obtain. (For information on the properties of laminates at temperatures up to 200 F see M/DE, Feb '58, p 109.)

Table 1, as well as other data presented by Norman A. Skow, of Synthane Corp., shows that some types of plastics laminates have excellent thermal endurance. These tests show that the thermal properties of laminates cannot be reliably predicted from the thermal properties of the individual materials of which they are made.

As shown in Table 1, Grades XX and LE laminates do not perform well at 180 C (Class H, 356 F) temperatures. However, Grade XXXP, a paper-base phenolic laminate, has remarkably good electrical properties and thermal endurance at 180 C. In addition, Grades G-5 and G-7 have excellent mechanical properties at this temperature. Grade G-10 (glass fabric, epoxy resin) is weak mechanically compared to G-5 and G-7. However, the recently developed G-11 laminate, similar in composition and electrical properties to G-10, is reported to be much stronger at high temperatures.

In order to find out how laminates could meet the requirements of AIEE Over 220 C (Class C, 428 F) insulating materials, a series of laminates was exposed to 250 C (482 F) for 1000 hr. As shown in Table 1, the Grade AA laminate could not withstand this temperature, but the GPO-1, G-5, G-7 and G-10 laminates fared much better. Even higher degrees of thermal endurance can be expected with new phenolic resin-

TABLE 1—PROPERTIES OF PLASTICS LAMINATES AFTER 1000 HR AT . . .

Grade ↓	180 C (355 F)[a]			250 C (480 F)[b]		
	Flexural Strength, psi	Dielectric Strength, v/mil		Flexural Strength, psi	Dielectric Strength, v/mil	
		Perpendicular	Parallel		Perpendicular	Parallel
XX	5,600	Blistered	170	—	—	—
XXXP	4,100	530	250	—	—	—
LE	400	Blistered	Blistered	—	—	—
LA	5,400	55	76	—	—	—
AA	—	—	—	800	Blistered	54
GPO-1	6,600	68	121	1,300	55	58
G-5	17,500	112	143	1,900	108	77
G-7	18,700	290	200	11,800	211	250
G-10	5,200	160	178	Not tested	112	100

[a]Properties measured at 180 C. [b]Properties measured at 250 C.

asbestos fabric laminates now under development.

Glass-polyester laminates recommended for switchgear

Glass-polyester laminates are gaining increased acceptance for electrical applications, notably for the structural and insulating components of switchgear. H. R. Sheppard, of Westinghouse Electric Corp., says the desirability of these materials stems from their: 1) high impact strength, 2) dimensional stability, 3) low moisture absorption, 4) low cost, 5) flame resistance, and 6) tracking resistance.

Composition of glass-polyester laminates can now be varied over a wide range to suit operating requirements. Mechanical properties as well as other properties can be readily adjusted. In addition to the original general purpose (GPO-1) grade, it is now possible to obtain several special grades of glass-polyester laminates (see Table 2) each developed to satisfy one or more switchgear requirements.

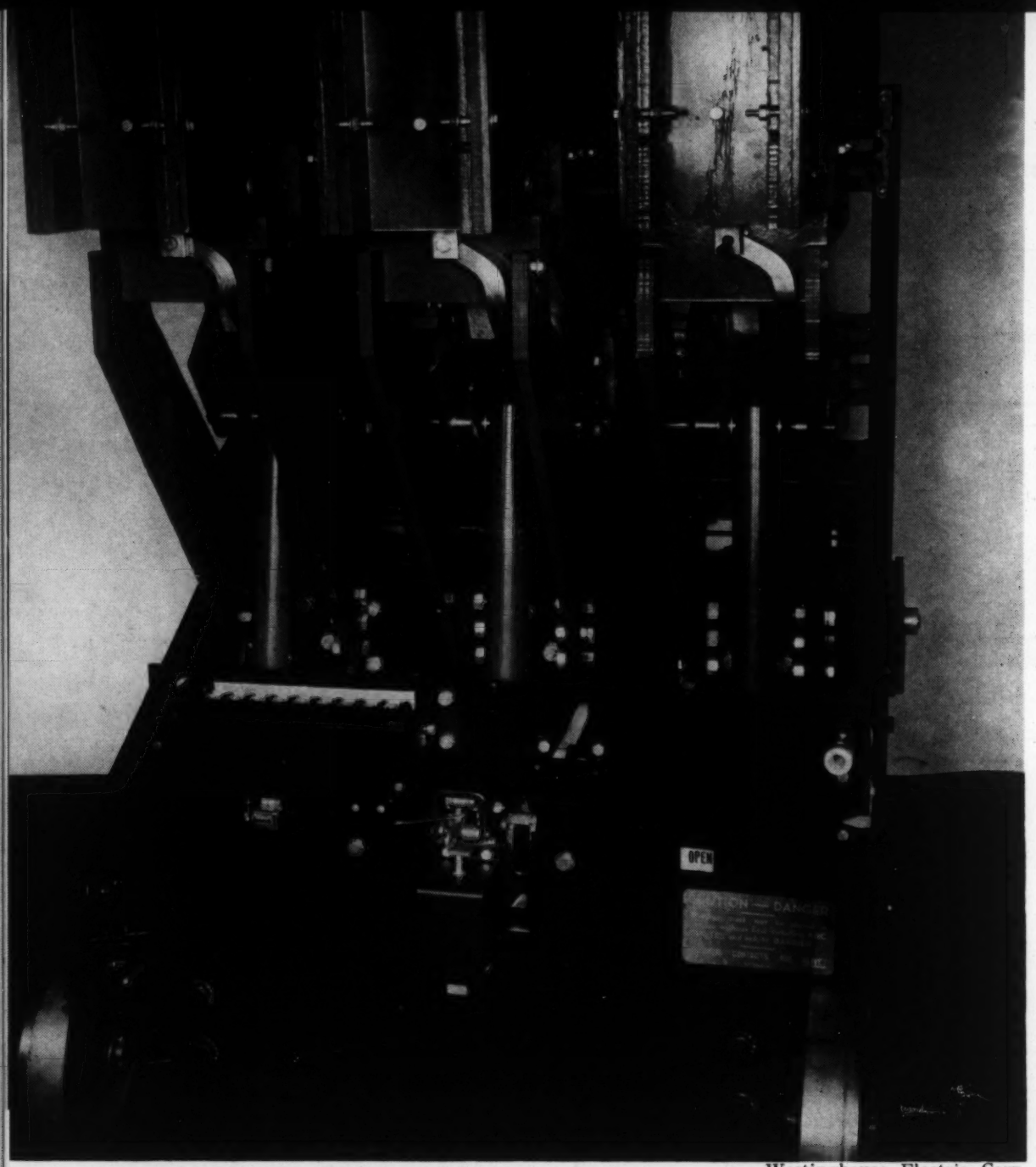
Fig 1 shows the great extent to which glass-polyester laminates can be used in switchgear. This magnetic air circuit breaker (13.8 kv, 1000 mva) uses a high strength, track and flame resistant glass-polyester laminate for the interrupter housing and the combination bushing and chute support. A similar laminate is also used for the interphase barrier (not shown).

TABLE 2—PROPERTIES OF GLASS-POLYESTER LAMINATES FOR SWITCHGEAR

Grade ➡	General Purpose	Flame Resistant, High Strength	Flame Resistant, Moderate Strength	Tracking Resistant
ELECTRICAL PROPERTIES				
Dielectric Strength (perp, short time, D257), v/mil	400-800	400	400	400
Dielectric Strength (step-by-step, D709), kv	40	40	40	40
Power Factor (60 cycles at 77 F, D150), %	2	2	2	2
Arc Resistance (D150), sec	100	110	110	110
Tracking Resistance (dust and fog test), hr to failure	—	—	—	50
MECHANICAL PROPERTIES				
Tensile Strength (D638), psi	9,000	12,000	9,000	12,000
Flexural Strength (D790), psi				
77 F	18,000	22,000	18,000	22,000
266 F	10,000	8,000	10,000	8,000
Compressive Strength (D695), psi	30,000	35,000	30,000	30,000
Izod Impact Strength (D256), ft-lb/in.	8	8	8	8
Rockwell Hardness	M100	M100	M100	M100
Bond Strength (D952), lb				
Condition A	850	850	850	850
Condition D	800	800	800	800
PHYSICAL PROPERTIES				
Specific Gravity	1.8	1.8	1.8	1.8
Water Absorption (D570), % in 24 hr				
1/16 In. Thick	1	1	1	1
1/16-1/8 In. Thick	0.7	0.7	0.7	0.7
1/8-1/2 In. Thick	0.35	0.35	0.35	0.35
Flame Resistance, sec				
Ignition Time	—	120	100	100
Burning Time	—	60	100	100

Moisture resistant melamine laminates

Despite the acceptance of G-5 glass cloth-melamine laminates for electrical insulation, users of these materials have often been handicapped by their comparatively poor resistance to water and humidity. There has been a constant demand to improve the moisture resistance of the G-5 grade. The Air Force, especially, has recently insisted on an improved G-5 laminate for use as fire detector tubes. There have also been a number of requests for improvement in the properties of fabricated sheets to be used as bases



Westinghouse Electric Corp.

Fig 1—*Glass-polyester laminates with high strength and track and flame resistance are used in key parts of this magnetic-air circuit breaker.*

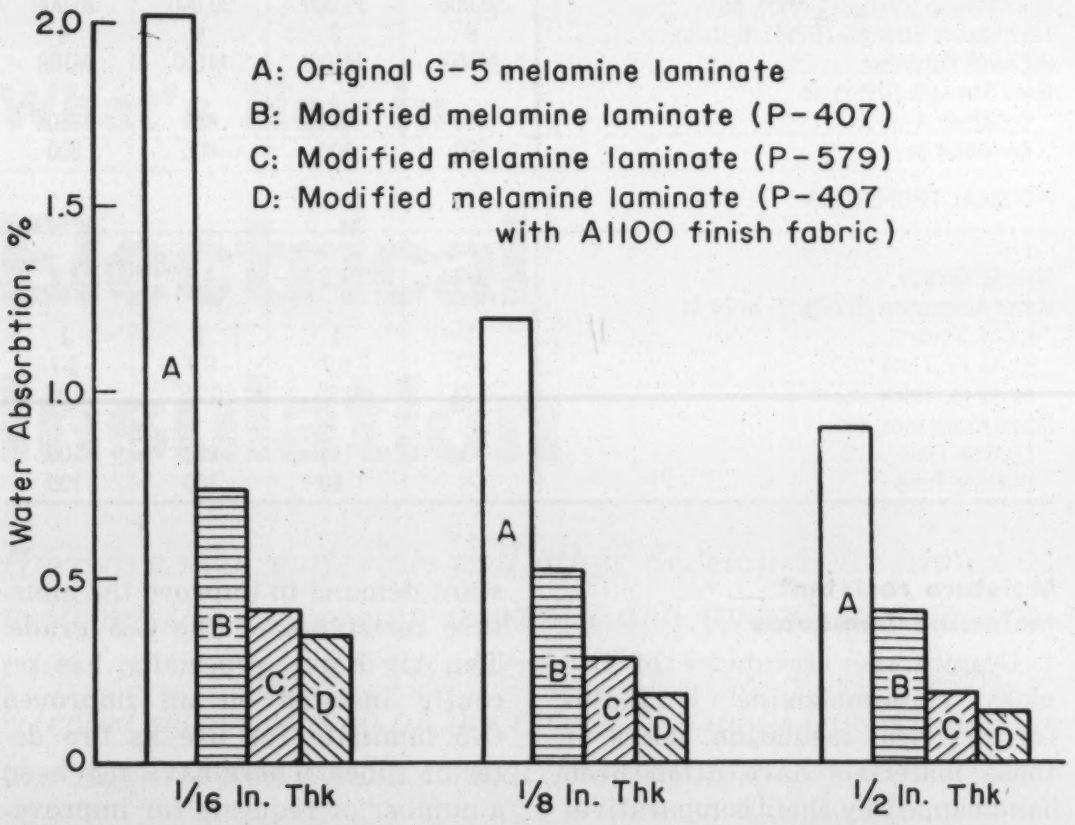


Fig 2—*Comparative water absorption of G-5 and modified melamine resin laminates. Resin changes clearly produce great improvement.*

for certain aircraft switches.

Recently completed work by Formica Corp., presented in a paper by J. C. Pitzer, shows that the properties of the G-5 laminate can definitely be upgraded through the use of modified melamine resins. Fig 2 shows typical changes which can be made in the water absorption of G-5 laminate merely by changing the resin. Properties of the laminate are also changed by surface finish; however, the improvements gained in this way are considerably less than those produced by resin changes.

Considerable improvement has been obtained in the dielectric strength of laminates exposed to water. To determine dielectric strength the standard immersion test D 48/50 (48-hr immersion in water at 50 C) was extended to periods as long as 336 hr. As shown in Fig 3, dielectric strength of the improved laminates after long immersion periods is more than twice that of conventional G-5 laminates.

Dissipation factor and dielectric constant of the modified melamine laminates also remain stable after immersion. One modified material (P-407) has a dissipation factor of 0.0202 and a dielectric constant of 6.8 after the D 48/50 immersion test. (For more data on electrical properties and craze resistance, see What's New in Materials, p 162.)

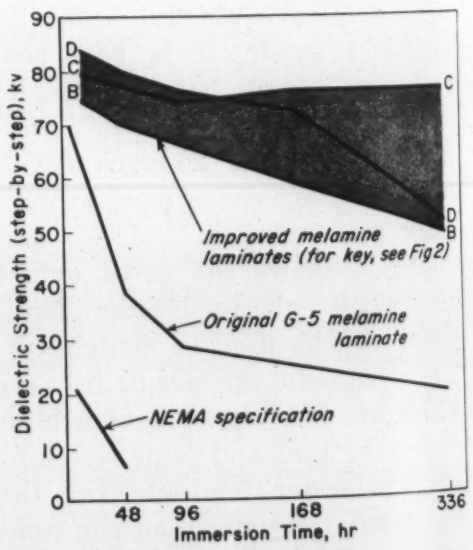


Fig 3—*Dielectric strength of G-5 and modified melamine resin laminates after extended immersion in water.*

Clad epoxy-glass laminates for printed circuits

In the past two years there has been a rapid increase in the use of epoxy-glass fabric laminates as a base for printed circuits. Until recently, printed circuit boards were made predominantly of XXXP paper-base phenolic, copper-clad laminate. However, as stated in a paper by Alfred J. Green, Joseph C. Pesce and Robert F. Bogart of National Vulcanized Fibre Co., new applications requiring greater dimensional stability, heat resistance and mechanical strength, have necessitated the development of metal-clad laminates to supplement the standard XXXP. Phenolic-glass, melamine-glass and silicone-glass laminates have been available for some time. Although copper can be bonded to these materials, the authors claim that each material has certain deficiencies which prevent any large scale use.

Table 3 gives a general comparison of the properties of the paper-base, copper-clad XXXP laminate and the G-10 and G-11 epoxy-glass, copper-clad laminates. Both the G-10 and G-11 laminates are much superior in mechanical strength, stiffness and dimensional stability to the XXXP laminate; they also cost about three times as much. The greater dimensional stability of the epoxy-glass laminates is largely due to their low water absorption and low coefficient of thermal expansion.

TABLE 3—COPPER-CLAD LAMINATES—PHENOLIC-PAPER VS EPOXY-GLASS[a]

Laminate ➡	Phenolic-Paper (XXXP)	Epoxy-Glass	
		G-10	G-11
High Freq Losses	6	10	10
Arc Res	1	10	10
Insul Res (C96/35/90)	9	9	10
Mech Str (rm temp)	2	10	10
Water Abs	5	10	10
Dimen Stability	2	8	10
Fungus Res	5	10	10
Heat Res	2	6	10
Str of Copper Bond	7	10	8
Res to Plating, Cleaning	4	10	10
Res to Dip Soldering	5	10	10
Ease of Fabrication	10	5	2
Thickness Tol	10	6	6
Cost	10	3	3

[a]Properties are rated from 1 (poor) to 10 (best).

The electrical properties of the epoxy laminates are not significantly better than for the best XXP materials when measurements are made at standard temperatures and humidities as high as 90%. There is some indication that the insulation resistance of both the epoxy and the XXXP laminates begins to drop off at temperatures of 390 F and above. The dissipation factor of the epoxy laminates is no higher at frequencies as high as 1000 mc than it is at 1 mc; in contrast, the dissipation factor of XXXP laminates rises fairly rapidly in the 300 to 500 mc range. Also, the superior arc resistance of the epoxy laminates can be advantageous in applications where the relatively low arc resistance of the phenolics has been a handicap.

Design suggestions for laminates in printed circuits

Selection of the best electrical laminate for printed circuits requires a thorough knowledge of the laminate's fabricating characteristics as well as its physical and mechanical properties. Factors which the designer should consider were set forth in a paper by William M. Bower of the Photocircuits Corp.

Thickness—The advantages of using laminates over 1/16 in. thick are greater strength and less possibility of warpage. However, selection of thick materials can often lead to a number of disadvantages:

1. The thicker the laminate, the greater the thickness tolerance, especially in glass-base laminates.
2. Fabrication of thicker laminates is more difficult, particularly where punching is required.
3. Plated-through holes are more difficult to produce in laminates thicker than 1/16 in.
4. Price increases with thickness.

Warpage—Laminate warpage is frequently encountered with one-sided circuitry and can create many processing problems. For example, if the laminate warps when heated there is great difficulty in handling the work in racks or holders. Other problems created by warpage are:

1. Dip solder machines are liable to give incomplete solder contact.
2. It is difficult to insert warped pieces into plug-in connectors.
3. Orientation becomes difficult in automatic component insertion equipment.

In general, lengthwise warp (with the grain) occurs less frequently than crosswise warp. Glass-reinforced laminates warp less than paper-base laminates. Some typical maximum warp values than can be expected for one-sided circuit laminates are:

Thickness, in.	Warpage, in./in.
1/16	0.025
3/32	0.020
1/8	0.012
1/4	0.006

In contrast, the warpage of two-sided laminates is about 0.005 in. per in. for all thicknesses. Thus, one method of achieving flatter circuits is to specify a two-sided copper laminate which can subsequently be stripped of copper on one side during the etching process. Also, it is best to use a glass-base laminate which has copper on both sides and has circuitry placed so that the conductor areas are close to being equal on both sides.

The heat applied to circuitry must be kept in mind. In some cases, warpage will be more severe after dip soldering. Also, if operating temperatures higher than 150 F are expected, the warpage can be expected to increase as the laminate ages. This is especially true when using plasticized materials.

Shrinkage—During processing, allowances must be made for shrinkage, particularly if the circuits are subject to thermal cycling. Shrinkage can cause problems with automatic component insertion equipment. Two important factors to be kept in mind are: 1) paper-base laminates may shrink 10 times more than glass-base laminates, 2) crosswise and lengthwise shrinkage are not equal.

Drilling—When drilling laminates, it is important to consider

the design of the drill and its speed and feeding rate, as well as the type of base material and its thickness. When using plated-through holes it is essential to drill holes that have smooth walls. The rougher the hole, the more uneven will be the subsequent plating. A complete study of cross section is necessary to determine the best material for drilling. Wide variations are possible between grades and even between batches of the same grade.

Punching—When designing a laminate for punching the following points should be considered:

1. Distance between edges of holes in paper-base laminates should be no closer than 1½ times material thickness; in glass-base laminates the minimum distance is the material thickness.

2. Hole diameters should be no greater than material thickness.

3. Hole size tolerances increase with material thickness and decreasing hole diameter.

4. Punching never creates as smooth a hole wall as drilling.

At present, plated-through holes of good quality cannot be obtained with punched glass-base and some paper-base laminates. However, specially developed "cold punching" materials in the XXXP and XXP grades have enabled the designer to obtain closer spacing and tolerances. Good punching properties are also exhibited by a new epoxy paper-base laminate.

Acrylic-coated glass fabrics

Acrylic resin-coated fabrics are relatively new insulation materials which, because of their balance of electrical, mechanical and chemical properties, are expected to find wide use for various types of electrical equipment, particularly for 130 C (Class B, 266 F) and hermetic equipment. Described in a paper by R. E. Fay, J. R. Huntsberger and R. L. Lester, of Du Pont, the insulations consist of glass fabric coated with an emulsion copolymer made from a combination of such monomers as acrylonitrile, unsaturated esters and/or unsaturated acids. Closely related emulsion copolymers also form bases for supplementary insulations, including wire enamels and impregnating varnishes.

Specific properties of the acrylic resin-coated fabrics are given in Table 3. Other outstanding properties of the insulations include:

1. Good thermal stability at 130 C (Class B, 266 F) temperatures. The materials may also be used for extended periods at temperatures up to 155 C (Class F, 310 F).

2. Satisfactory electrical properties at 130 C under conditions of high humidity.

3. High resistance to most common solvents, lubricating oils, transformer oils, fluorinated hydrocarbon refrigerants, etc.

4. Based on preliminary tests, good resistance to nuclear radiation.

Acrylic resin-coated fabrics are now used to advantage in rotating equipment designed to operate at 130 C. They are also being used in hermetically sealed motors in refrigeration equipment where they are exposed to refrigerants and oil mixtures. The resistance of the materials to liquid and gaseous solvents is also expected to be useful in new types of oil or gas-filled transformers.

Silicone rubber-coated glass cloth for transformers

In a paper reviewing the excellent electrical, mechanical and high temperature properties of fully cured silicone rubber-coated glass cloth, L. M. Smith, of New Jersey Woodfinishing Co., concludes that this insulation would be suited to 180 C (Class H) transformers. Silicone - coated glass cloth has: 1) long life at high operating temperatures and electrical ratings, 2) excellent electrical properties, including corona resistance and voltage endurance, 3) excellent chemical properties, 4) high thermal conductivity, 5) resistance to vibration and thermal shock. In addition, it can be easily applied.

Because of these and other properties, silicone rubber can be expected to be particularly useful in transformers subject to mechanical and thermal shock, contamination, moisture and electrical overloads. The material also insures freedom from fire and explosions. Sealed dry-type transformers using silicone rubber-coated glass cloth are completely noninflammable and explosion-proof. Such transformers can be used in close proximity to generators, thus cutting down the use of costly bus bars.

Insulations for ultra high temperature wire

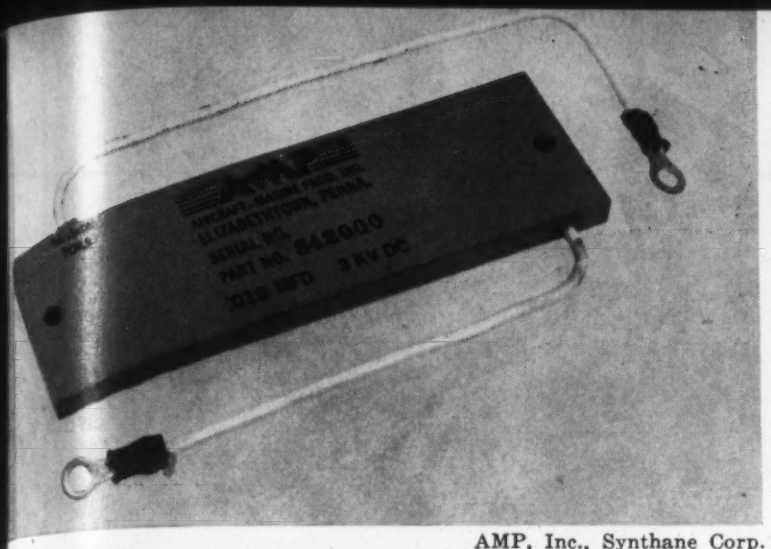
Increasing aircraft operating limits, now reaching beyond speeds of Mach 2 and altitudes of 150,000 ft, are creating a whole new set of insulation requirements. How these requirements can be met by current and proposed insulation systems was discussed by Allen Hubbard III, of Lewis Engineering Co.

New requirements—Future operating temperatures of insulations are expected to range from —100 to +1000 F. Service voltages will range up to 440 v, 3-phase, 400 cycles, and pressures from sea level to altitudes over 150,000 ft. Naturally, insulation weight and size must be kept to a minimum and materials must be resistant to fluids and solvents. Furthermore, insulations must be flexible and have better than average abrasion resistance and mechanical strength, with no degradation of properties during long periods of operation. In addition, resistance to nuclear radiation may be required.

TABLE 4—PROPERTIES OF ACRYLIC RESIN-COATED FABRICS[a]

Thickness →	14 Mils	7 Mils
Tensile Strength, psi	250	120-140
Crease Tensile Strength, psi[b]	135-160	20-30
Ultimate Elongation, %		
Normal Dir	<4	<3
Bias Dir	40	35
Dielectric Strength, v/mil[c]	800	850
Dielectric Constant (1000 cps, 77 F)	4.7	4.9
Dissipation Factor (1000 cps, 77 F)	0.035	0.043
Volume Resistivity, ohm-cm	1.3×10^{15}	1.5×10^{14}

[a]Lecton. [b]Creased with a 10 lb roller. [c]ASTM D295-55T short-time test, ¼-in. electrodes.



AMP, Inc., Synthane Corp.

Epoxy-glass *G-10 laminate possessing excellent combination of electrical and mechanical properties is used to encapsulate this video coupling capacitor.*

E. I. du Pont de Nemours & Co., Inc.

Acrylic-coated glass fabrics *are well suited for refrigerator coils because of their good electrical properties, heat stability and chemical resistance.*

Fired inorganic coatings—It has been proposed that an excellent insulation system could be obtained by using fired alumina, zirconia or magnesium oxide. These materials can be flame sprayed directly on conductors. Alternatively, they can be dispersed in resin binders (such as silicones or epoxies), dip coated on the conductor, and then heated and fired to remove the binder and fuse the frit. Another possibility is the extrusion of suitable lubricated ceramic coatings directly on the conductor, followed by prefiring to remove the lubricant and then high temperature firing to fuse the coating. Some manufacturers have combined the above materials with glass, Refrasil or asbestos to produce excellent thin insulations for coil, transformers and low voltage circuit wiring, the entire circuit or component being fired after assembly into a rigid structure. The disadvantages of this system are lack of flexibility and relatively poor resistance to thermal and/or mechanical shock.

High temperature claddings—Another way of meeting expected requirements is through the use of a high temperature insulating material such as magnesium oxide which is clad with copper, stainless steel or other high temperature metal. In this system the insulation, in a compressed but unfired state, is threaded over the conductor. The metal cladding is then placed over the insulation and the whole assembly swaged to produce a tight bond between the components. This system, though meeting most of the requirements outlined above, has certain inherent weaknesses. These are: cracking of the sheath, limitation on length, end leakage, poor resistance of terminals to damage, and an increase in capacitance caused by the continuous metal sheath.

Multilayer construction—Another promising insulation system consists of a layer of asbestos, glass or quartz fiber adjacent to the conductor as a thermal, mechanical and to some extent, dielectric barrier. This layer could be suitably impregnated with silicone varnish which, though not temperature stable in the higher ranges, converts into silicone dioxide which in itself is an excellent high temperature insulator and void-filling compound and does not leave a carbon residue. The silicone-impregnated layer could then be followed by: 1) a layer of mica for dielectric strength, 2) a binder layer of asbestos, glass, or quartz fibers impregnated with silicone varnish, 3) a braid coating of glass, quartz fibers or Refrasil to hold the insulation in place and under compression, and 4) finally, a thin unfired ceramic coating for abrasion resistance.

Precured pressure sensitive electrical tape

A new concept in the formulation of pressure sensitive electrical tapes promises to speed the production of electrical components. Ordinarily, a certain length of time is required to cure conventional thermosetting electrical tapes at an elevated temperature. However, with the development of new precured tapes it is possible to eliminate time-consuming bake cycles. According to S. J. Kaswand and R. Korpman, of Permacel-Lepage's, Inc., the precured tape not only eliminates the problem of insufficiently cured tape, but also anticipates future requirements of shorter prebake cycles. Although the adhesive of the new tape is precured, it develops more adhesion, with little or no pressure, than conventional adhesives.

The precured adhesive is more resistant to varnish solvents than conventional, fully cured thermosetting electrical tapes. A xylol-thinned electrical varnish will not dissolve a precured adhesive; however, it will slowly attack a fully cured thermosetting tape adhesive. The additional solvent resistance of the precured tape is valuable since it minimizes both varnish contamination and loss of tape holding power.

Another desirable advantage of precured tape is that its adhesive remains firm with increasing temperature. The tape exhibits less adhesive flow and better holding power at prebake temperatures than conventional thermosetting tapes.

The most important advantage of precured tapes is that performance characteristics are available as the tape comes off the roll. Additional heat treatment is not required to develop desired performance. Reliance need no longer be placed on prebake cycles which are not and cannot be designed to fully cure tape.

Koehler Aircraft Products Co.

Liquid oxygen *and other liquid gases at temperatures down to –320 F are handled by this gate valve.*

Selecting Solders for Low Temperature Service

Here are the types that seem best for use with liquefied gases, based on tensile and impact data.

by A. B. Kaufman, *Chief Development Engineer, Arnoux Corp.*

■ New soldering problems for the engineer are resulting from the increasing use of liquefied gases at temperatures of –450 to –300 F for missile applications. The effect of low temperatures on strength and ductility is a major consideration in the selection of a solder for such service.

Lead solders

Based on tensile and impact strength, two lead solders (97.5 lead-2.5% silver and 95 lead-5% tin) are suitable for cold environments. As shown in Fig 1, these alloys increase in both strength and ductility with falling temperature.

In marked contrast are the properties of a 50 lead-50% tin solder, given on the same graphs. Although tensile strength increases with decreasing temperature, the solder becomes brittle; impact strength falls from 16 ft-lb at 80 F to 1 ft-lb at –300 F.

BOILING TEMPERATURES OF LIQUEFIED GASES[a]

Gas	Temp, F
Argon	–302
Helium	–452
Hydrogen	–423
Nitrogen	–320
Oxygen	–297

[a]760-mm Hg absolute pressure.

HOW COLD AFFECTS STRENGTH OF SOME SOLDERS

Tradename	Nominal Composition, %	Tensile Strength, psi	
		80 F	–320 F
LEAD SOLDERS			
*	Pb 95, Sn 5	3,500	9,200
	Pb 75, Sn 25	7,400	18,000
	Pb 67, Sn 33	7,600	20,000
	Pb 50, Sn 50	6,200	17,600
*	Pb 97.5, Ag 2.5	4,500	9,600
*	Pb 97.5, Ag 1.5, Sn 1.0	3,600	9,000
TIN SOLDERS			
	Sn 90, Pb 10	7,600	16,000
	Sn 60, Pb 40	8,000	17,000
Cerrocast	Sn 48, Pb 36, Bi 16	6,000	1,000
Claude-Michael #275	Sn 45, Pb 32, Cd 18, Bi 5	8,750	7,925
*	Sn 95, Sb 5	5,800	12.600
INDIUM SOLDERS[a] (compositions not available)			
*Indalloy #1	In 50, Sn	1,050	6,125
*Indalloy #2	In 80, Ag, Pb	2,050	6,250
*Indalloy #3	In 90, Ag	2,050	5,100
*Indalloy #5	In 25, Pb, Sn	5,100	12,250
*Indalloy #7	In 50, Pb	3,050	4,075
*Indalloy #10	In 25, Pb	4,100	7,150

*Presently used or potentially valuable for low temperature services.

Unfortunately, the high lead solders are difficult to use, particularly with a rosin flux. Replacement of part of the silver in the recommended lead-silver solder produces an excellent solder that can be used with rosin fluxes. Tensile properties of this 97.5 lead-1.5 silver-1% tin solder are given in the accompanying table.

Lead-tin solders

The tensile strengths of a series of lead-tin alloys are given in Fig 2. Highest strengths at low temperatures are obtained with the alloys containing more than 50% lead. Although the strength of these alloys increases with falling temperatures, this relationship does not always hold with alloys containing tin and lead. For example, Table 1 gives the properties of two proprietary tin solders containing lead and additional elements; both of these alloys decrease in strength with falling temperature.

Rentention of ductility at low temperatures in lead-tin alloys is a function of the lead content. Tin undergoes an allotropic transformation and becomes brittle under long-time service below –18 F. Increasing the lead content of lead-tin alloys progressively lowers the minimum temperature at which these alloys are ductile; above about 70% lead, the alloys should remain ductile to temperatures near absolute zero.

Although tin and high tin-lead alloys become brittle at low temperatures, a 95 tin-5% antimony alloy remains stabile at low temperatures because the antimony prevents the allotropic change in the tin. Tensile properties of this alloy, given in Table 1, show an increase in strength with falling temperature.

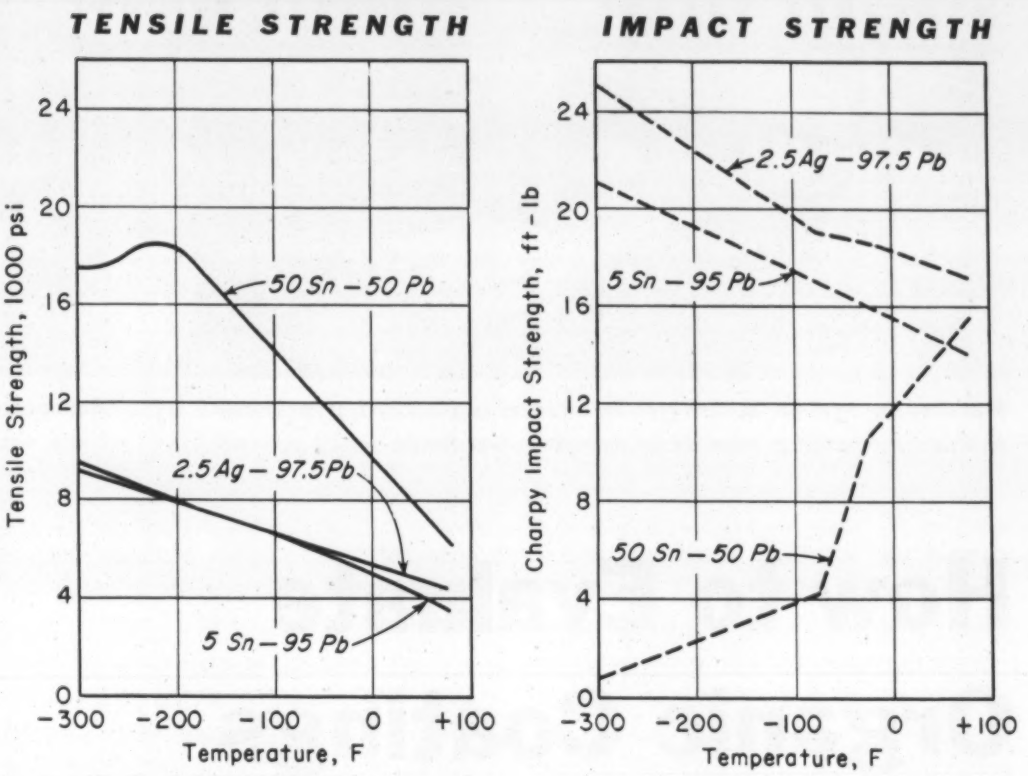


***Fig 1**—Tensile and impact strengths of lead-base solders are markedly influenced by composition.*

Indium solders

Solders containing indium are also worthy of consideration for low temperature applications. These alloys can be used to solder many metals and alloys that cannot be successfully soldered by the lead-base solders. Tensile properties of a number of indium solders, given in Table 1, show that strength increases with falling temperature. Impact tests indicate that the 50% indium-lead alloy is the best of the group for low temperature service.

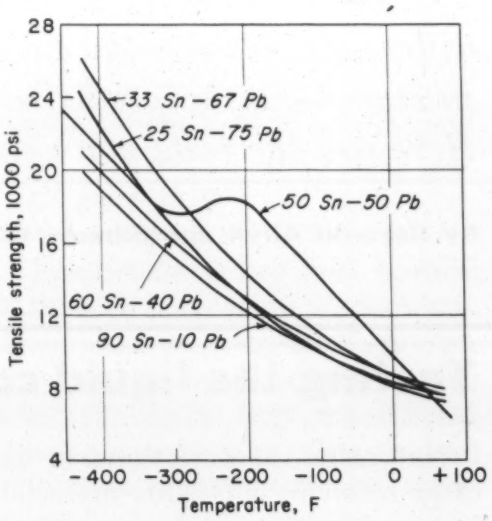


***Fig 2**—Lead-tin solders containing more than 50% lead are the strongest at low temperatures.*

Other Selection Factors

In addition to strength and ductility, a number of other factors enter into the selection of a solder for low temperature service. These include:

1. *Stability*—Resistance to allotropic changes is necessary if long term service is required.

2. *Environmental compatibility*—Compatibility of a solder in a liquid oxygen medium implies that no explosion will occur under ignitor action such as mechanical shock. Many solders are inert in the absence of igniter action; for example, a number of lead-tin solders are sensitive only when subject to impact. Residues from soldering fluxes must be removed for compatibility in liquid oxygen.

3. *Corrosion*—Although many solders may be excellent in other respects, the requirement that corrosive fluxes be used to produce satisfactory joints may make them undesirable for low temperature service.

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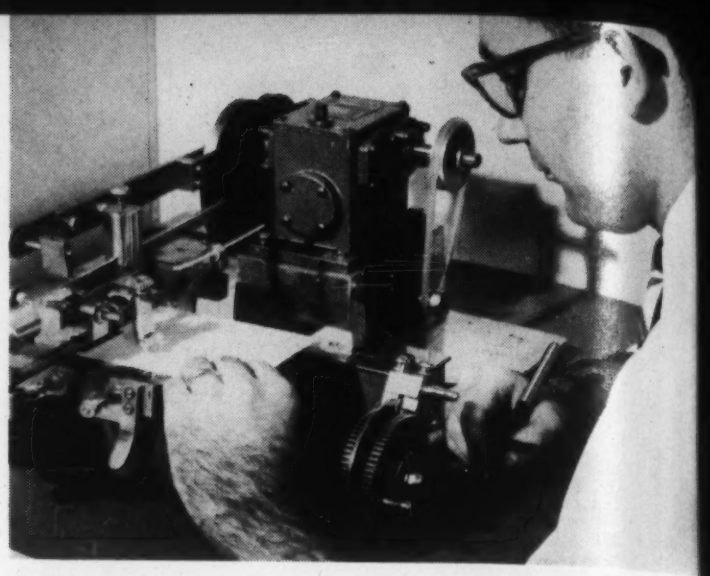
***Hardness** can be measured by scratching coated panels with a series of drawing pencils of varying hardness.*



***Adhesion** is measured by how close parallel lines can be scored before failure occurs.*

How to Evaluate Organic Coatings

The performance of an organic coating—often the difference between the success and failure of a product—can be predicted by standard tests. Here are the tests you need to know.

by Gerould Allyn and Samuel Gusman, *Rohm & Haas Co.*

Testing the liquid coating

Naturally, the first thing to do after receiving a coating material is to open the container and examine the material for appearance, odor and stirring characteristics. Also, most users put a small amount of paint on a spatula and work it out into a thin film on a glass plate to measure smoothness. Though valuable, all of these tests are purely subjective and several other simple tests are usually required to determine the quality of the material as supplied.

Viscosity or consistency

The viscosity or consistency of a coating is very important in determining product appearance. If the coating is too low in viscosity (too thin) it will run off or sag on vertical surfaces. Furthermore, it is difficult to apply thin coatings in sufficient quantity to give adequate protection and suitable appearance. Some coatings are supplied at a viscosity suitable for application; others must be thinned before application.

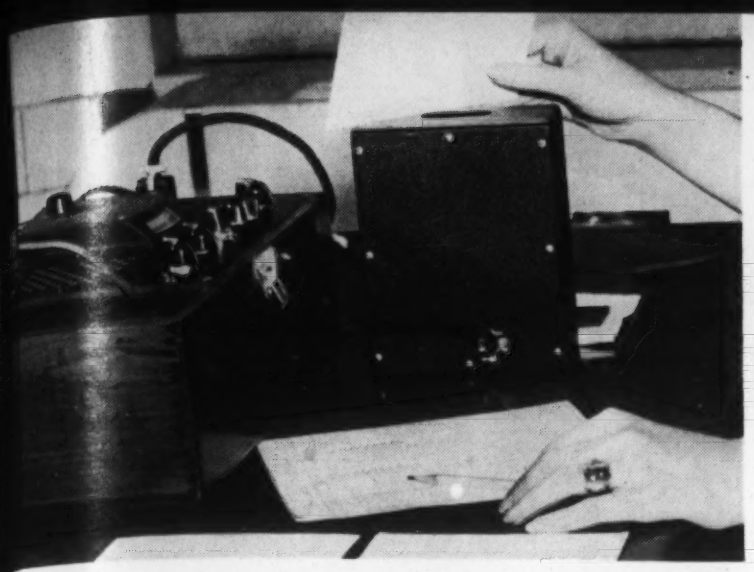
The viscosity of coatings is often measured in poises or centipoises (1 cp = 0.01 poise). Water, for example, has a viscosity of about 1 cp at room temperature. Coatings reduced with thinner for spray application often have viscosities in the range of 0.5 to 1.0 poise. Viscosity values range from 0.5 up to 3 or 4 poises for dip application, and up to 5 to 10 poises for brush application. Exact values for each application method depend on the composition of the coating and the amount of film to be applied.

Viscosity or consistency can be measured by three major tests:

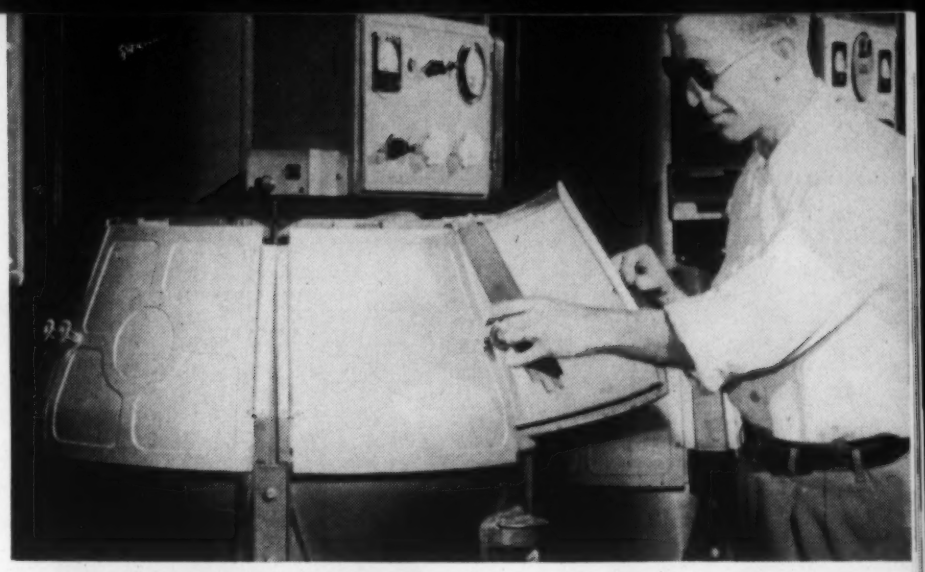
Air bubble test—The instrument (typified by the Gardner-Holdt Bubble Viscometer) consists of a set of glass tubes which are partially filled with liquids of predetermined viscosity. The tubes are inverted and the rise of bubbles in the standard tubes is compared with the rise of bubbles in similar tubes filled with the material under test. The test is usually used for clear, rather than pigmented, coatings. Results can be expressed either in poises or in an arbitrary series of letter standards ranging from A (0.5 poise) to Z_6 (148 poises).

Torsion test—A number of torsion-type instruments are available for measuring consistency by means of a rotating cup or suspended paddle. In the rotating cup method, consistency is determined by measuring the torsion induced in a wire-hung bob placed in a rotating cup containing the coating material. In the paddle method consistency is determined by measuring the rotating speed of a paddle in the test liquid. Poise values can be calculated, or the results can be expressed in arbitrary Krebs units. Values of 65 to 85 Krebs units are common for brush-applied coatings.

Efflux test—Standarized efflux cups with fixed orifices are available in various sizes but they all work on the same principle. The cup is filled with the coating liquid and the time required by the liquid to flow out is measured. Viscosity can be expressed as the number of seconds to empty the cup, or in poise values. Coatings suitable for spray viscosity take about 20 sec to efflux from a cup



Gloss *is determined by measuring amount of light reflected from coating at a fixed angle.*



Fading resistance *is determined by exposing panels to carbon arc which produces intense ultraviolet radiation.*

such as the No. 4 Ford cup, commonly used in viscosity measurements. Efflux cups operate best at low viscosities.

Weight per gallon

This is simply a measure of coating liquid weight and provides a good indication of solids or pigment content. Liquid weights vary widely. Clear coatings often weigh about 8 lb per gal. Enamels run 9 to 11 lb per gal, and primers with high red lead or iron oxide content run to 20 lb per gal.

Weight per gallon can be determined by weighing a filled gallon measure or a small filled cup. A standard 83.2-ml cup is very convenient; the net weight of the coating liquid in grams, when divided by 10, gives the liquid weight in lb per gal.

Flash point

Flash point is important in establishing the fire hazard of a coating during storage and application. The most common way of determining flash point is the Tag Closed Cup Method. A cup is filled with the coating liquid, gas flame is applied to the vapor over the liquid, and the temperature at vapor flash is recorded.

Most lacquers and similar fast drying coatings thinned with toluol or other low boiling solvents flash well below 80 F. Coatings made with xylol flash above 80 F, and if the coating is thinned with mineral spirits it will generally flash above 100 F.

The Interstate Commerce Commission requires that a red label be placed on containers of organic coatings with a flash point below 80 F that are shipped between states. Other safety regulations are also in effect. The New York City Fire Dept., for example, classifies coatings with flash points below 100 F as flammable, and those with flash points between 100 and 300 F (Tagliabue Open Cup Method) as combustible.

Liquid color

The color of transparent coating liquids is usually determined by comparing samples with standard liquids. A number of color standards are used. Among them are the Gardner Color Standards, a series of 18 standard tubes filled with liquids ranging in color from very pale straw to dark brown. Good clear lacquers have colors as low as 2 to 3 on this scale; some water white acrylic lacquers have a rating less than 1. Clear alkyd coatings may have a color from 4 to 10, varnishes 10 to 14, and raw linseed oil about 12.

The color of liquid pigmented coatings is also determined by comparison with a reference color standard, of which there are a considerable variety available. The Federal Government uses a standard series given in Specification TT-C-595. Every paint manufacturer has a color card of the standard colors he offers, and most of these permit intermixing.

Fineness of grind

Pigments should be finely ground and well dispersed in the vehicle to provide a smooth uniform consistency. A rough test for fineness is to draw down a small amount of the coating on a glass plate and examine the film for any large particles.

A more exact method is to use a fineness gage such as the North Standard Gage. This instrument consists of a blade and a steel block with a milled channel varying in depth from 0.000 to 0.005 in. A drop of the coating is placed in the channel and drawn down with the blade. The film is then inspected to determine the point where it first shows an uneven appearance. This point is given a corresponding scale value reading from 0 to 8. A fineness of 6 is usually satisfactory for high gloss grinds.

Total solids

Practically all coatings contain a thinner to provide workability. Many inexpensive coatings can turn out to be expensive in the long run since they contain excessive amounts of thinner and minimum amounts of film forming vehicles and pigments.

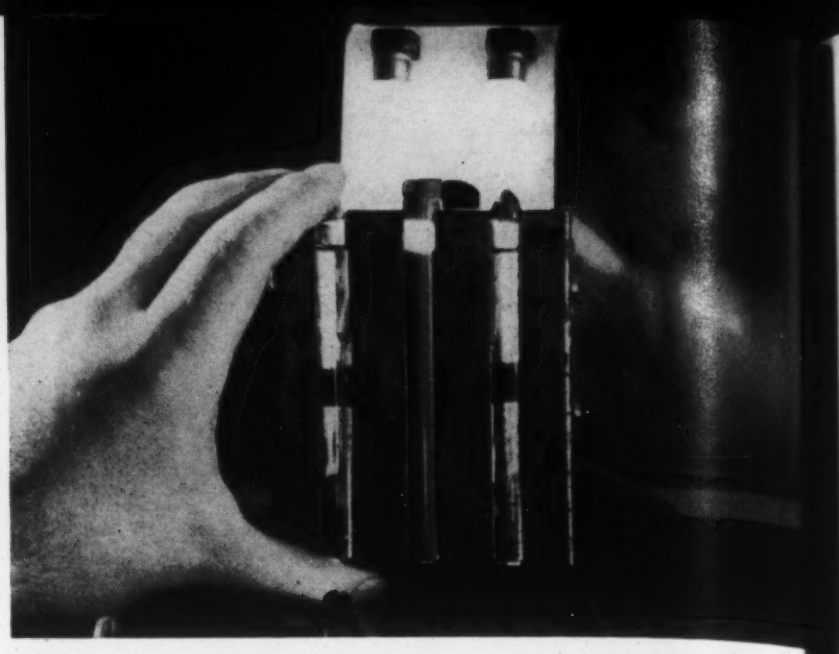
Solids content is easily determined by heating a small weighed sample of the liquid coating in a dish. The weighed residue remaining after heating is the solids content and is expressed in percent of the original sample.

Good quality white baking enamels for metals often have a solids content as high as 55 to 60% before thinning. Good clear varnishes have about 50% solids, and lacquers range in solids from 20 to 30%.

Other tests

Many additional tests are available for analysis and quality control of liquid coatings. They include further pigment tests, as well as tests on acid number, dilution stability, amount of phthalic anhydride and nitrogen resin, etc.

***Thickness** of coating on magnetic surfaces can be measured with magnetic gage which does not mar coating.*



***Color** of transparent lacquers or varnishes is determined by comparing samples with liquids of standard color.*

Testing the coating during application and drying

If the coating passes all of the above tests satisfactorily, the next question is: how will it perform during application and drying?

Application properties

These properties are usually determined by visual inspection. The coating should be reduced with the required thinner and applied to either test objects or panels. Surface preparation, application techniques and film thickness should duplicate actual production conditions. After application the film should be inspected for uniformity and general appearance. When properly applied, the coating should not show any color differences, and should not run, sag or streak.

Drying properties

It is important to know the times required for an air-drying coating to set, to become dust-free, to become tack-free, and to dry hard. A coating is considered to have set and be resistant to dust pickup when the finger can be run lightly over the surface without picking up any paint. Lint is sometimes scattered over the panel to see if it adheres to the surface.

A coating is considered to be tack-free if it is not sticky and does not become marked when pressed lightly with the finger. The coating is considered thoroughly dry if it does not wrinkle or loosen after the thumb is pressed against it with maximum pressure and turned through 90 deg. In addition, the coating must, of course, be resistant to wrinkling, loss of gloss, whitening or other surface defects during drying.

For baked coatings the baking speed and the hardness attained at a given time and temperature are very important. These properties are usually measured by testing hardness after various baking schedules.

Testing the dried coating for appearance

A number of factors enter into the appearance of a coating, some of which are quite subjective. Some characteristics are more easily determined by visual inspection. However, attempts have been made wherever possible to establish appearance characteristics on a quantitative basis.

Hiding power

The hiding power of a coating is extremely important. Hiding power depends largely on the amount and type of pigment in the coating, and on its thickness.

A simple comparative method of determining hiding power consists of applying the coating over a specially prepared substrate, such as white and black paint test charts. Such charts show the ability of a paint to obscure the line of demarcation between the white and black areas.

The hiding power of a wet coating can be measured with a Pfund Cryptometer. This device consists of a black and a clear glass plate placed at a fixed angle to each other; the resulting wedge shape is filled with the paint under test. When you look through the clear side, the black plate is visible through the paint near the thin apex of the wedge. However, further along the glass plate the wedge-shaped layer of paint is thick enough so that the black background becomes completely hidden. At this point a value for hiding power in square feet per gallon is determined on a scale.

Unfortunately, the hiding power of a wet film does not always correlate exactly with that of a dry film. Nevertheless, the method is useful in many cases.

Gloss

The gloss of a coating is usually determined by measuring its reflectance. A number of devices (such as the Gardner and Photovolt equipment) illuminate the surface with a standard light at

a fixed angle (usually 60 deg) and measure the amount of reflected light with a photocell. The amount of reflected light is then compared with that from a standard polished glass surface.

A gloss value as high as 90% of that observed with a polished (Carrara) glass plate is often obtained with high gloss baking enamels. Semigloss coatings usually fall in the range of 40 to 70%. Values for low gloss finishes are even lower, ranging down to nearly zero for the flat finishes.

Color

It is well known that the apparent color of an object depends on the nature of the illumination. For example, two materials that appear to be the same color under artificial light may appear quite different in natural light.

A number of standard lighting systems have been developed to eliminate this problem. Two widely used methods—photoelectric-abridged spectrophotometry and photoelectric tristimulus colorimetry—also permit quantitative non-visual measurement of color. The abridged spectrophotometry method uses several spectral filters and a photoelectric device which isolate spectral bands and measure the wave length of reflected light. The tristimulus colorimetry method also uses filters but measures color in terms of brightness and purity as well as wave length. A general description of the standard test method is given in ASTM D307-44.

Both of these methods are used where precise measurement and specification of color are required. However, in many cases satisfactory results can be achieved by specifying color from a color dictionary. Such specified color can be compared fairly accurately with the color of a sample under test.

Depth

So-called "depth" and "fullness" of coatings are difficult to measure and are best judged by visual comparison. These factors are related to the observer's ability to recognize the exact location of the surface and judge how far below the surface the color appears to be.

Testing the dried coating for performance

Thickness

Close control over coating film thickness is essential because of the important effect thickness has on performance. Film thickness can vary widely, depending on appearance requirements and end-use conditions.

Though thickness is most commonly measured on dry films, it is occasionally measured on wet films. Wet film thickness is obtained by measuring the diameter of the spot produced on a convex lens when it is pressed against the wet film. Thickness is calculated from the diameter of the spot and the curvature of the lens. An instrument of this type is known as the Pfund Gage. Thicknesses can also be converted to coverage in square feet per gallon of coating.

Dry film thickness is easier to measure on metallic surfaces than on nonconducting surfaces. Two types of measuring devices are available:

Penetration test—This type of instrument (typified by the Gardner gage) consists of a fine wire probe which penetrates the coating. When the coating is completely penetrated, the probe, which forms part of an electric circuit, contacts the metal substrate and causes an indicator light to flash. Film thickness is then read directly on a micrometer scale attached to the probe.

Magnetic test—Magnetic thickness instruments are very convenient but can only be used on ferromagnetic substrates such as iron and steel. Two such instruments are the Magne-Gage and the General Electric Thickness Gauge. The Magne-Gage utilizes a torsion wire through which a force is applied to remove a magnet from the coated surface. After proper calibration, thickness is determined by measuring the force required to remove the magnet. The General Electric Gauge measures thickness directly by measuring the flux in the vicinity of a magnet placed on the coated surface. Both of these methods are rapid and give reasonably reliable and precise values.

Hardness

A number of different methods are available for measuring hardness.

Sward Rocker test—This test measures the damping of a rocker which is set into oscillation on a coated surface. The number of swings of the rocker is counted during damping from one predetermined amplitude of oscillation to a lower predetermined amplitude. Sward hardness values from about 26 to 50 are commonly obtained with baked coatings on metals.

Wilkinson pencil test—This test utilizes a series of chisel-pointed drawing pencils ranging from soft to hard as follows: 6B, 5B, 4B, 3B, 2B, B, HB, F, H, 2H, 3H, 4H, 5H, 6H, 7H and 8H. Each pencil is firmly pressed against the coating and the number of the softest pencil that does not cut through the coating is designated as the pencil hardness. Hardness values from F to 2H for metal finishes indicate good resistance to marring.

The pencil test is widely used and is of considerable value. However, precision is sometimes lost because of the variation in pencils of a common grade, the difference in the shape of the pencil point, or the angle at which the pencil is held.

Tukon test—This test utilizes a standard (Knoop) diamond indenter. Hardness is determined by measuring the size of an indentation produced by a diamond point of specific size and shape impressed into the coating by a predetermined load after a set time. Though the Tukon method

is considerably more precise than the Sward or pencil methods, cost of the testing equipment required is much higher.

Descriptions of other tests for measuring hardness can be found in the specifications listed as references in the accompanying box.

Adhesion

Adhesion is an extremely important property of organic coatings. However, it is a difficult property to measure. Various complicated research methods have been used, but at the present time no completely successful, low cost method is available for measuring adhesion. Nevertheless, some simple adaptations of knife or tape adhesion tests can be used with good results.

Simple scratch tests—The adhesion of an organic coating is most commonly measured by scratching it with a coin or knife. Adhesion is judged to be good if the coating is difficult to remove. Adhesion is poor if the coating chips off easily in large flakes. Actually, this type of test and the others listed below do not measure interfacial bond strength alone since the strength of the film itself is also involved.

Tape test—This adhesion test involves scoring of the coating with a series of cross-hatched lines using a sharp knife or razor blade. A piece of pressure sensitive tape is then placed on the scored area and rubbed firmly in place with a pencil eraser. The tape is then removed rapidly, the degree of adhesion being measured by the amount of coating removed by the tape.

Arco Micro Knife—This test is more quantitative than the tests described above. A diamond point is used to score a series of parallel lines through the coating. The minimum distance between the lines at which failure first occurs is noted. Knowing this distance and the load on the diamond, an estimate of adhesion can be obtained. This estimate correlates reasonably well with scratch and knife tests.

Adherometer test—This and similar tests make use of a chisel-shaped blade which cuts through the coating. A platform supports the coated panel which is drawn past the edge of the blade. The blade is supported by a device which measures the force of the cutting action. This force is then correlated with the thickness of the coating to give an estimate of adhesion.

Where to Obtain Coating Specifications

1. Federal Specification TT-P-141b lists more than 200 test methods for coatings. Available from Supt. of Documents, Washington 25, D. C. (price $1.25).

2. Other Government specifications. See "Guide to Materials Standards and Specifications, Part 6—Coatings and Finishes," M/DE, Aug '58.

3. ASTM Standards, Part 4. Available from Am. Soc. for Testing Materials, 1916 Race St., Philadelphia.

Flexibility

Film flexibility is commonly measured by bending a coated panel over a mandrel or rod which may have a diameter varying from $\frac{1}{8}$ to $\frac{1}{2}$ in. Another device known as the Erichsen film tester is also sometimes used. This test measures the depth of indentation at the failure point when a steel ball is pressed againt the reverse side of a coated panel.

Impact resistance

Impact resistance is often an important characteristic and is usually measured by allowing a given load to fall on a coated panel from various heights. The point at which failure occurs is given as the measure of impact resistance in inch-pounds. A variety of other impact tests are available for specific applications. Automotive coatings, for example, are often tested by subjecting them to a high velocity stream of gravel.

Abrasion resistance

Abrasion resistance can also be tested by a variety of methods. The Tabor Abraser Test, which utilizes an abrading wheel, is quite popular. Abrasion resistance can be measured by the number of cycles to wear completely through the coating. Alternatively, the weight loss of the coating after a specified number of cycles of abrasion can be used. Another typical abrasion test consists of dropping a stream of sand or other abrasive material onto a panel from a given height.

Resistance to exposure

Various tests are available for measuring the resistance of organic coatings to actual exposure conditions. Tests can be performed to measure resistance to staining and blistering by a host of materials such as water, dyes, foods, detergents, alkalis, organic solvents, acids, etc. Also, exterior durability tests can be used to measure such properties as gloss retention, resistance to mildew attack, and freedom from cracking, checking and blistering.

In general, exposure tests are best run under conditions that simulate actual operating conditions. However, for simplicity it is often necessary to standardize on an arbitrary set of test conditions.

Attempts to duplicate outdoor exposure tests have had moderate success. A variety of accelerated test instruments such as the Weatherometer can be used. Such instruments are helpful in comparing similar materials, but can sometimes be misleading when comparing different materials.

References

In addition to the three sources cited in the accompanying box, the following references were used:

Bidlack, V. C., and Fasig, E. W., *Paint and Varnish Production Manual*, John Wiley and Sons, '51.

Catalogue of Testing Instruments for the Paint and Other Industries, Gardner Laboratory, Inc., Bethesda, Md.

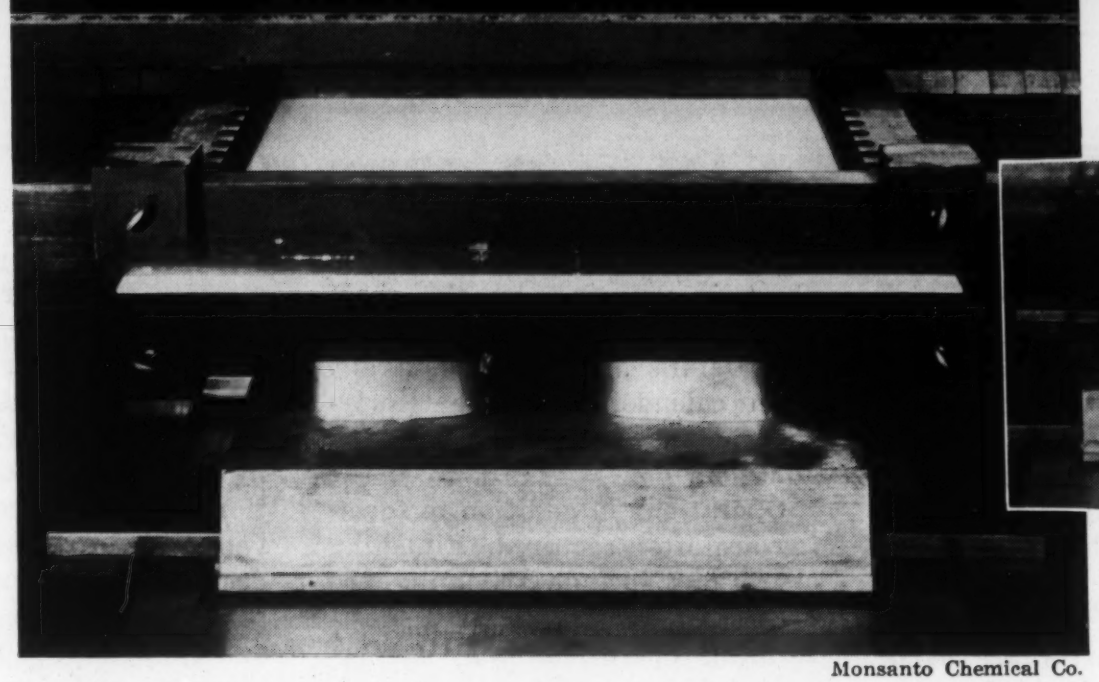
Gardner, H. A., and Sward, G. G., *Physical and Chemical Examination of Paints, Varnishes and Lacquers*, Gardner Laboratory, Inc., Bethesda, Md.

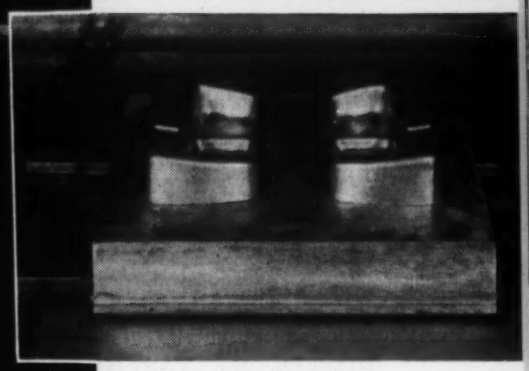
Gardner, H. A., and Sward, G. G., *Paint, Varnish, Lacquer and Color*. Available in most libraries, this book is currently out of print but is being revised for publication.

Official Digest, Federation of Paint and Varnish Production Clubs, Philadelphia.

Payne, H. F., *Organic Coating Technology, Vol. 1*, John Wiley and Sons, '51.

Protective and Decorative Coatings, Vol. IV and V, edited by J. J. Mattiello, John Wiley and Sons, '46.





1. *Sheet is positioned over male mold (see inset).*

Monsanto Chemical Co.

Drape vacuum forming is one of many ways to produce . . .

Sheet Formed Plastics Parts

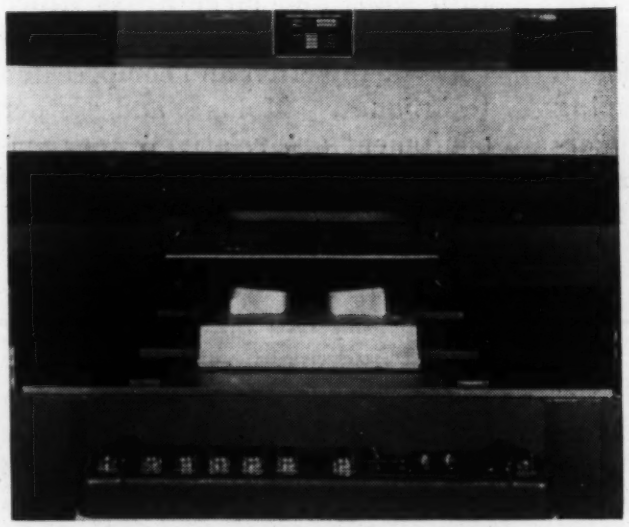
by **Jack C. Merriam,**
Associate Editor,
Materials in Design Engineering

Parts molded from thermoplastic sheet offer wide materials selection, attractive appearance, predecoration, speed of production set-up, and economies in manufacture. This manual tells:

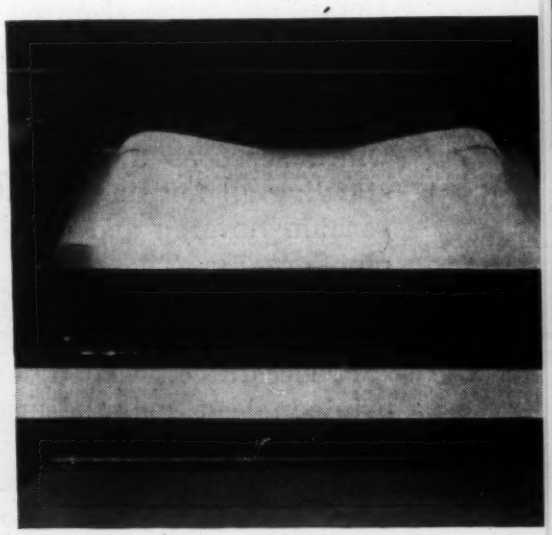
- *Why sheet formed parts*
- *Which type of sheet*
- *Which thermoplastic material*
- *Which forming method*
- *What design limitations*

Materials
in Design Engineering

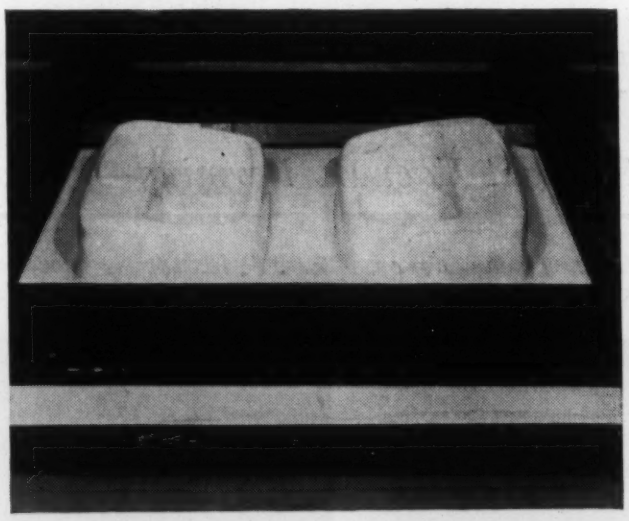
Manual No. 154
November 1958



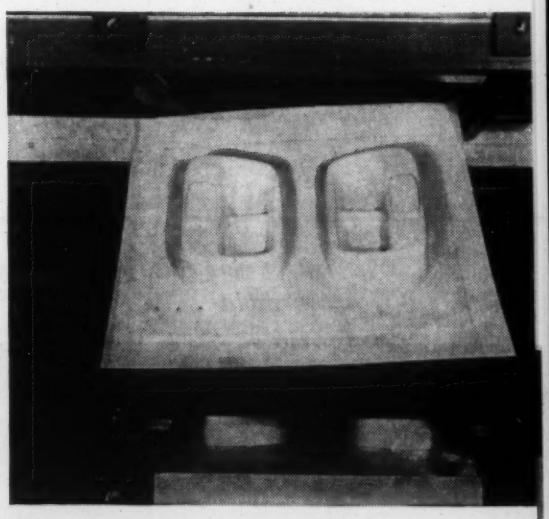
2. *Heater is positioned above sheet.*



3. *Frame drapes hot sheet over mold.*



4. *Vacuum is created within mold area.*



5. *Part is removed after cooling.*

Why Sheet Formed Parts?

"Forming," or "thermoforming," is the term applied to a variety of techniques used to manufacture complex-shaped articles from thermoplastic sheets. The heat-softening nature of the plastic is utilized by rapidly forcing the heated sheet into shape and allowing it to cool until rigid again.

What they are

Sheet formed parts are parts formed: 1) mechanically, but this is generally limited to simple bends and beading; 2) by male and female die pressing, which produces excellent parts but is expensive and takes time; 3) by air pressure, which is the newest method and gaining acceptance as tougher materials are developed and deeper draws required; 4) by vacuum, which is the basic, common method. Two fundamental techniques of vacuum forming which serve as a key to understanding all forming are straight vacuum forming and drape vacuum forming. These two techniques are illustrated on this page and on the previous page.

Predecorated, coated or preprinted sheet may be used for forming. This is a major advantage of sheet formed parts. "Predecorated sheet" refers to sheet purchased with some type of applied pattern such as a wood-grain finish. "Coated sheet" is also purchased as such and usually refers to metallized sheet. "Preprinted" sheet is prepared by the sheet former (see box on "Some Process Details", p 133) generally from calendered and matte-surfaced blank sheets for best ink adhesion.

Operations in addition to forming are often required. Finishing operations include trimming the excess flange from the part. Post-forming operations may be required for undercuts and formed-over sections. Other operations may include: application of protective, decorative or antistatic coatings; planishing; overlamination; cleaning and polishing; cementing, bonding or heat sealing.

Their advantages

Formed parts may have very thin walls and large areas which are beyond the mechanical limitations of injection and compression techniques. Molds and other equipment are relatively inexpensive compared with molds for injection and compression molding.

Speed is another advantage of most forming techniques. Complete items can be accurately designed and produced within a few weeks. The speed of forming techniques is the reason they are often used to produce prototypes for injection molded items even though the final production run will be more economical on the molding machines.

Although sheet formed parts occasionally compete with molded plastics parts, or replace wood, glass, metal, etc., their largest use has been for newly created products. Whether forming is done mechanically, by vacuum or by air pressure—or by a combination of these—it offers many advantages from the standpoint of design, production and use of products in such fields as packaging, appliances, automobiles and aircraft, and for such specialty items as toys, hobby equipment, counter displays and Christmas decorations.

When to choose them

Except in a limited number of borderline applications, sheet molded parts are not competitive with injection or compression molded parts. Instead of replacing such parts, they often increase the feasibility of injection or compression molded parts by serving as economical prototypes for test and redesign before the production run.

In most cases, the choice between molding and forming is clear-cut, depending first on the design and wall thickness of the part, and second upon economic factors. Runs over 100,000 generally prove most economical when molded, if design allows, for three reasons: the long run will absorb the higher tooling cost; material costs are considerably lower; and supplementary finishing operations are minimized.

Straight Vacuum Forming—Female Mold

***1.** Sheet is clamped by airtight frame over female mold . . .*

***2.** . . . heater is positioned above sheet until it is uniformly softened . . .*

However, new products may be formed until sales justify the molding setup; and some large-run products may always be formed because of the part design and size.

Sheet formed plastics parts should be considered if they require:

1. A large area, particularly if combined with thin walls.
2. Minimum residual strain.
3. High impact strength in thin-wall sections.
4. Low volume production and low price.
5. Probable design changes, e.g., adding bosses, ribbing.
6. Predecoration.
7. Quick production setup.
8. Deep drawing with good detail; undercuts; inserts.
9. Mechanical assembly by riveting, cementing, etc.
10. Certain strength characteristics or chemical resistance found in formable sheet.

Their future

Most of the forming processes in use now are relatively new to industry (sheet forming, itself, was not widespread until 1950). Three factors have predominated in the growth of sheet formed parts:

1. Relatively low cost extruded sheet has largely replaced more expensive cast or calendered sheet.
2. Low cost materials formulations have been marketed expressly for thermoforming; higher impact materials are available; sheet finishes have been improved.
3. Automatic, rapid-cycle machines which both heat and form (and may be part of an extrusion-forming-trimming setup) have been developed to allow the use of one or more forming techniques.

In all three areas developmental work is still proceeding and still vital to an industry in which more than 1,500 machines turn out over 85 million pounds of plastics products annually. Every day increased use is being made of the advantages inherent in sheet formed plastics parts—speed of production setup, economy of manufacture, wide selection of materials to satisfy end service requirements, feasibility of predecoration, and the attractive appearance of the product.

Which Type of Sheet?

Thermoplastic sheet is available in a variety of materials and gages (including film). Characteristics of the sheet depend to some extent on whether it is produced by extrusion, casting, calendering or other methods.

Extruded sheet

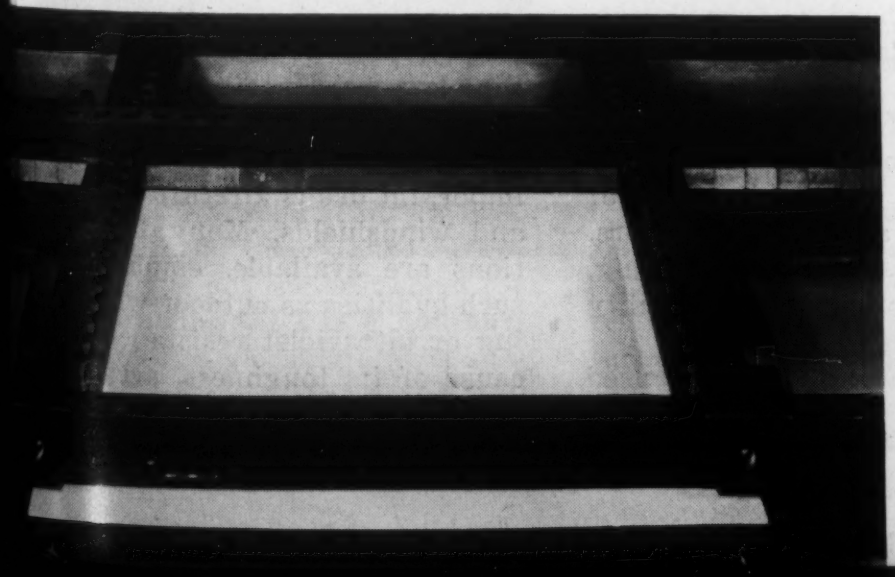
Extruded sheet is the most used. Production is simple and economical, and many sheet formers install their own extruders, often set up to feed directly into the forming machine. Drawbacks of extruded sheet are that it may have greater variations in thickness than other types and that extrusion lines or flaws may be present. All materials used for formable sheet may be extruded, and the method is common for all but the vinyls.

The extrusion process involves feeding the material in pellet form into a hopper where it is preheated and dropped into a screw mechanism which forces it through a heated barrel and then through a die at the opposite end. The sheet is generally produced in thicknesses from 0.010 to 0.250 in.

After extrusion, the continuous sheet is either rolled on a paper core (thin gages) or cut into sheets. The extruders may incorporate other attachments which perform such operations as laminating a film to the sheet, heat glossing the sheet surface, or embossing a design.

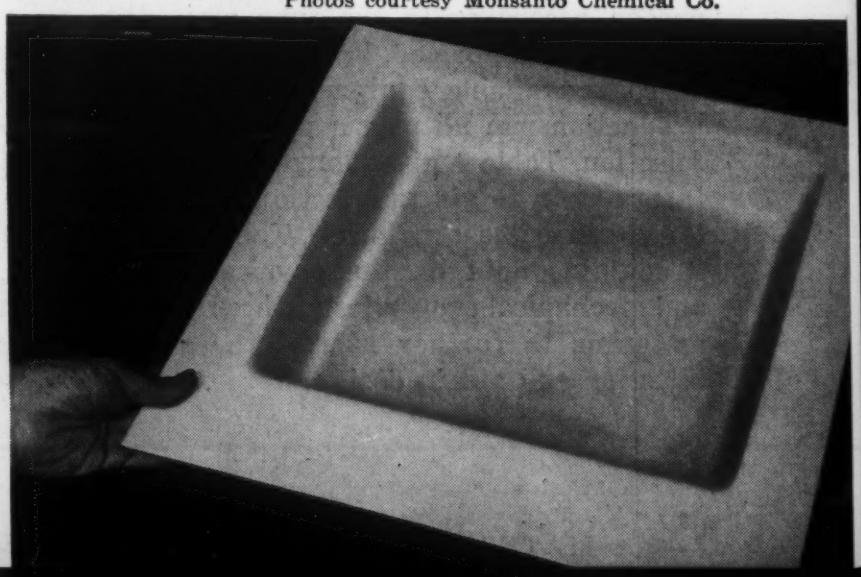
Orientation after extrusion is sometimes used to produce sheet with special characteristics. The term refers to stretching of circular sheet with accurate control of the final diameter. The result is an increase in tensile and impact strength (and sometimes clarity) which allows the use of thinner sheet. Common thickness range of oriented sheet is 0.0025 to 0.02 in. Materials commonly

3. *. . . air is exhausted from mold area and atmospheric pressure forces plastic against contours . . .*



4. *. . . part is removed after cooling, reverse air pressure being used to strip part from mold.*

Photos courtesy Monsanto Chemical Co.



oriented include acrylic, styrene and polyester film.

Calendered sheet

Calendering—passing the material through a series of heavy rolls—is generally used for thinner gage sheets, particularly the vinyl polymers and copolymers, and sometimes the styrene blends. High pressures are used and the thickness of the sheets can be controlled to close limits, thus making sheet forming easier and allowing deeper drawing. Laminating of calendered sheet is sometimes done to increase the thickness, combine different materials, or obtain special properties.

Cast sheet

One of the oldest methods of sheet production, casting yields a high quality sheet which is usually harder than that produced by the other methods. In addition, the absence of strain produces high optical clarity in applicable materials. Sheet thickness is limited only by the size of the mold; sheets up to 3 in. thick have been cast.

A common method of casting is to polymerize the material to a viscous syrup which is mixed with sufficient catalyst for subsequent polymerization. The syrup is run into a mold which is heated by a hot water bath, then allowed to solidify. For thin sheets the block may be planed, slicing off sheets of desired thickness, although today the material is usually cast to size. Sheets may be further processed to remove residual solvents or polished by pressing with highly polished platens. Films may be cast directly on a heated metal belt, or cast on paper. Vinyl film, acrylics and cellulosics are cast, although cast cellulosic sheet is not used extensively for forming. Cellulose nitrate, the first sheet available and once extensively formed by steaming, is highly flammable and therefore seldom used today in sheet forming.

Coated and predecorated sheet

Metallized sheet, which can also be color coated, is extremely popular. Most common is cellulose acetate or cellulose acetate butyrate sheet which has been given a bright, hard coating of silver or aluminum in a vacuum chamber. Although the sheets must be heated on the opposite side, forming and preprinting take place in the usual manner.

Clear plastics films can be metallized—or given other decorative effects such as gloss, wood grain and similar patterns—and laminated face down to the sheet for protection against wear or corrosion. A notable example is metallized Mylar laminated to flexible vinyl. The same protection results from laminating a clear film to a coated or decorated sheet.

Grain, wood and leather effects are available on vinyl, modified styrene and ABS plastics. The patterns are accomplished as described above, i.e., by printing on the sheet or laminate. Grained materials find use in luggage, displays and packaging.

Sheets which have been flocked after extrusion produce a beautiful, contoured part with a velvety coating. Such parts are used extensively for displays. Flocking has been used mainly on sheets of styrene copolymer.

Other effects available on purchased formable sheet (such as glossing, laminating, press polishing, satin finishing, flame polishing, frosting, pearlizing, and embedding) are discussed in connection with the particular material.

Which Thermoplastic Material?

Many plastics are available in sheet form. Specific evaluation is difficult because there are many formulations of the same material, often tailored to meet specific end-service requirements; because the sheet may have been produced by any of several methods; and because the formability may depend on the forming method and conditions. In general, a material is chosen according to the type of product to be formed, but factors of cost, available equipment and production run all play a part in selection. Table 1 gives important information to aid in selection of the common sheet materials. Table 2 contains data on the physical and mechanical properties of these materials to further narrow the selection and aid in design.

Acetate, butyrate

Cellulose acetate and cellulose acetate butyrate have been available for years but have only recently gained wide acceptance for sheet forming. Cellulose acetate was difficult to form by vacuum until the development of formulations designed for the purpose. The development of pressure forming may see increased use of the older, harder formulation. Cellulose acetate butyrate was expensive until the development of an extruded form. Both materials have good impact resistance and are available in a wide range of transparent and opaque colors. Butyrate has better forming, moisture absorption and solubility characteristics.

Cellulose acetate is now used more than any other clear material, though its outdoor applications are limited due to its high moisture absorption. Of predominant interest are the wide use of cellulose acetate for blister packaging and the extreme ease with which butyrate can be predecorated.

Acrylics

Although cast acrylic is one of the costliest sheets, in quantity sold annually it is topped only by the low-cost modified styrenes. Outstanding for its optical clarity and high strength, acrylic's most important use is aircraft canopies and windshields. Many formulations are available, emphasizing such qualities as outdoor weathering or ultraviolet resistance. Because of its toughness, acrylic is

difficult to form on most standard machinery and generally requires greater pressure than vacuum forming affords.

Extruded acrylic sheet is available at about 60% the cost of cast sheet, and is easier to form, but it has lower strength and optical qualities.

Oriented extruded acrylic sheet is less brittle than cast sheet and provides high clarity and strength in thin gages. It is used primarily for panel lighting construction.

All forms of acrylic sheet are easily predecorated. The cast form can be supplied pearlized or cast with embedded decoration.

Styrenes

This is the lowest cost group of sheet materials because of its ease of extrusion and low specific gravity. It is with these materials that many sheet formers tie in the extrusion process.

Styrenes are available in several basic formulations. Straight polystyrene is extremely brittle and is not produced in heavy gages. It requires careful handling during forming. Because of its transparency and high heat resistance, its major use is for lighting panels.

Modified styrenes include a range of materials based on straight polystyrene modified through chemical reaction, alloying, or simple mechanical mixing with other plastics or with rubber. The terms "styrene copolymers", "impact styrenes" and "rubber-modified styrenes" are also used for part or all of this group to distinguish it from the ABS plastics (see below).

The modified styrene group, being the lowest cost material, is the real workhorse of the sheet forming industry and is used in practically every field. It is easily formed, has good strength, and has good resistance to abrasion by household cleaners. Formulations have been developed which preprint easily, and sheet can be obtained with wood grain finishes. The material does have drawbacks: it is not the best sheet for deep drawing; it has a dull surface unless a glossing unit is added to the extruder or a thin film of oriented polystyrene is laminated to the surface, it is not available in transparent form, although translucent formulations have been developed; and it has limited outdoor use.

ABS terpolymer

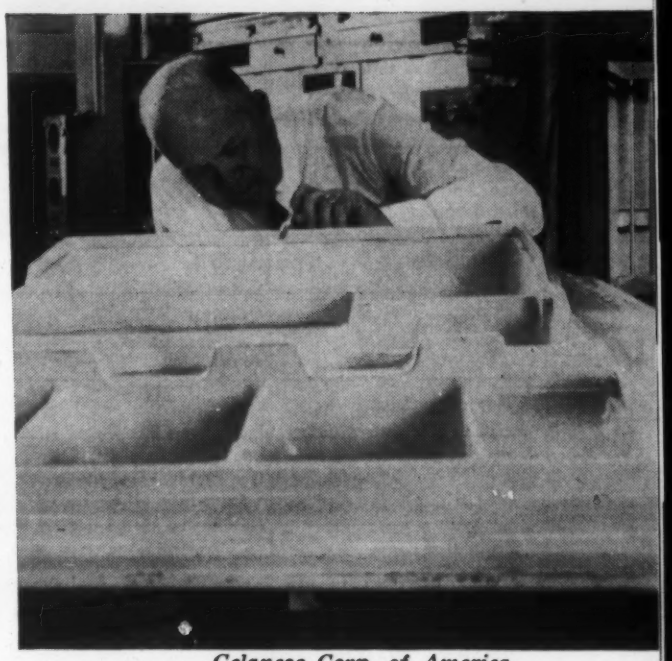
Acrylonitrile-butadiene-styrene, which is a modified styrene, has become competitively active enough within the past year to necessitate separate designation. The requirements of the applications for which the ABS materials are used are generally more exacting than those for the modified styrenes. ABS provides high strength, good corrosion resistance and electrical properties. The range of formulations makes possible high dimensional stability at temperatures as low as –50 F or as high as 230 F. Gaining applications in every field, particularly luggage, the material is readily lacquered, enameled and printed. Its cost, however, is nearly twice that of the modified styrenes, and it requires costlier forming equipment than straight vacuum forming machines.

Oriented polystyrene

Filling the gap between brittle straight polystyrene and nontransparent styrenes, this material provides high strength and clarity in thin gages. It is used for lighting applications, signs, and packaging. Not easily formed by vacuum methods, it generally requires pressure forming with close control of heating and timing. It can be easily preprinted, but the selection of ink and solvent is particularly important because some may attack the surface of the sheet and result in crazing and embrittlement.

Vinyls

Polyvinyl chloride in the calendered, laminated form has been available for some time; it is a premium material of high strength and durability, but at above-average cost. Available either as a high impact or a superior corrosion resistance type, it is used considerably for outdoor or industrial applications. The extruded form is gaining popularity now that the difficulties of extrusion have been overcome.



Celanese Corp. of America

***Refrigerator door liner** is formed from polyethylene sheet by pressure snap-back method which provides more uniform wall thickness than straight drape forming.*

Chicago Molded Products Corp.

***Portable dishwasher** was made by laminating a 20-gage white modified styrene sheet to a heavier gage black sheet, then vacuum forming.*

Vinyl copolymer (vinyl chloride-acetate copolymer) is rapidly gaining in popularity despite its above-average cost. When produced by calendering it has extremely close dimensional tolerance and stability, making it ideal for parts requiring deep drawing or preprinting. It retains perfect preprinting uniformity throughout the production run, is adaptable to all preprinting processes, and has a durable, color-retaining, abrasion resistant surface;

TABLE 1—FACTORS TO CONSIDER IN

Material →	Cellulose Acetate	Cellulose Acetate Butyrate	Methyl Methacrylate	Polyvinyl Chloride	Vinyl Chloride-Acetate Copolymer
Major Forms Used	Extruded	Extruded	Cast, extruded[a]	Calendered and laminated, extruded	Calendered[b]
Cost, $/lb[c]	0.96	1.08	1.88	0.75	0.75, 1.30[d]
Thickness, in.	0.002-0.250	0.001-0.375	0.020-3.0 (cast), 0.040-0.125 (extr)	0.035-0.500 (cal), 0.010-0.030 (extr)	0.002-0.040
Maximum Width, in.	60	72	100 (cast), 54 (extr)	30	75
Clarity	Transparent to opaque	Transparent to opaque	Transparent to opaque	Transparent to opaque	Translucent to opaque
Color	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited
Finish	Glossy std, matte available	Glossy std, matte available	Glossy, cast with embedded decoration	Matte to press-polished, grained	Matte, satin finished[b]
Advantages	Good impact resistance and toughness; clarity and good colors; resists aging; no odor; good formability; metallizes well; good printability	Same as cellulose acetate with improved impact resistance, lower moisture absorption, easier formability	Many formulations for specific service; high strength and optical clarity; outdoor weathering and ultraviolet resistance	Good impact and excellent weather and corrosion resistance; good aging characteristics	Excellent dimensional stability and strength; good for deep drawing and particularly for accurate registration preprinting
Limitations	Limited outdoor use due to high moisture absorption; depth of draw somewhat limited	All around balance of properties but not outstanding in any one; slight odor	Difficult to form, pressure better than vacuum; one of the costliest materials; extruded form has lower quality but is less costly and easier to fabricate	Formability critical; requires longer heating cycle; costs considerably more than acetates	High density; limited thickness but can be laminated; weatherability not as good as butyrate; looses flexibility at —25 C
Uses	Packaging; also displays, toys, eye shields, jewelry, food tray liners	Outdoor signs, housings, glass substitute in hazardous areas, outdoor phone booths	Aircraft and boat canopies, domes and windshields; also outdoor signs, lighting	Chemical resistant hoods, developing trays; film for food packaging	Signs, displays, Xmas decorations, maps, novelties, toys

[a]Also oriented in gages from 0.010 to 0.020 in. with max width of 42 in.
[b]Also press-polished and laminated in gages from 0.002 to 0.500 in.; this form is available in clear transparent sheet and used for packaging.

as a result, it is used for more than half of the sheet formed preprinted products. Although not transparent as calendered, it can be press-polished to a high transparent gloss. Press-polished vinyl film is laminated to the sheet to obtain higher gloss.

Polyethylenes

Lower density (or "straight") polyethylene, comparable in cost to modified styrenes, has been a latecomer in the sheet forming field. It is felt that a considerable degree of selectivity is required in choosing end uses where the properties of polyethylene are of optimum value. Polyethylene has extreme toughness over a wide temperature range, complete freedom from toxicity, and excellent resistance to chemical attack. In clarity it is a somewhat milky translucent sheet and colors tend to be pastel rather than solid. Formulations are now being tailor-made for specific forming applications.

Processing characteristics are, to some extent, different from those of other forming resins in both the sheet extrusion and the forming operation. The higher specific heat means the sheet requires more heat to reach forming temperature. Double heater banks, above and below the sheet, and a means of controlling mold temperature have proved feasible. Polyethylene is easy to trim because it does not crack.

Higher density (also "linear" or "low pressure") polyethylene is similar to straight polyethylene but has higher stiffness, dimensional stability from —180 to +250 F, and more brilliant coloring. The same forming factors must be considered. A relative newcomer to the field, it has a high potential.

Both forms of polyethylene must have special surface treatment before stamping or silk screening operations can be performed.

Films

Films (gages up to 0.008 in.) of many materials are also formed and the discussion of sheet materials and forming methods generally applies to them. Materials include cellulose acetate, cellulose acetate butyrate, polyethylene, polystyrene, flexible vinyl and oriented polyester (the polyethylene terephthalate type known as Mylar). The last two have not been previously discussed.

Straight Polystyrene	Modified Styrenes	ABS Terpolymer	Oriented Polystyrene	Lower Density Polyethylene	Higher Density Polyethylene
Extruded	Extruded, cast, calendered	Calendered, extruded	Extruded	Extruded	Extruded
0.59	0.51	0.80, 1.10[d]	0.80	0.68	1.24[e]
0.040-0.125	0.010-0.250	0.010-1.0 (cal), 0.010-0.375 (extr)	0.001-0.020	0.001-0.375	0.001-0.375
72	72	56 (cal), 54 (extr)	42	72	48
Transparent	Opaque, some translucent[c]	Opaque	Transparent to opaque	Milky translucent to opaque	
Unlimited	Unlimited	Unlimited	Unlimited	"Natural" is std; colors on order	
Glossy, flame polished, frosty or satin	Dull; can be glossed or grained	Matte to glossy; also grain	Glossy	Matte to glossy	Glossy
High tensile strength and heat resistance; good dielectric properties; high colorability; excellent moisture resistance; low cost	All-purpose general sheet for forming; lowest cost; good strength; excellent abrasion resistance to household cleansers	High strength, good corrosion resistance and electrical properties; excellent dimensional stability; readily lacquered or printed	High strength and clarity in thin gages; fills gap between nontransparent copolymer and brittle straight polystyrene	Can be tailor-made for specific use; low cost; tough and resistant to chemical corrosion; free from taste, odor, toxicity	Same as straight polyethylene, but semi-rigid and thus has higher impact strength; dimensional stability from —180 to +250 F.
Extremely brittle and thus not produced in thin gages; forming requires careful handling	Limited outdoor uses; not as good for deep drawing as some others; special formulations needed for good preprinting	Cost above average; less rigidity than other styrenes, so forming is somewhat difficult; requires better equipment than straight vacuum	Not easily formed by vacuum, generally requires pressure; selection of ink for preprinting particularly critical	High creep; low heat distortion temperature; poor cementing properties; forming requires double heater bank and temperature controlled mold	Cannot be bonded; forming difficulty same as straight polyethylene; high shrinkage rate (0.020-0.040 in./in.); pretreatment required for printing
Lighting panels, illuminated products	Every product field not requiring transparency, particularly household	Industrial items, automotive parts, appliances, potentially luggage	Lighting, packaging; laminated to polystyrene copolymer for gloss	Food and chemical packaging, housewares, lab equipment, toys	Light diffusers, luggage, safety helmets, electrical parts

[c]Approximate cost based on quantity order, 0.060 in. or nearest available size, uncolored, no special finish, for major form stated first (above).
[d]Calendered and pressed. [e]Based on ⅜-in. thick sheet.

Flexible vinyl is cast in gages from 0.002 to 0.008 in., calendered in gages from 0.004 to 0.040 in. The cast form is used for place mats, bath mats, wallets, book covers, etc. The calendered form is used particularly for skin packing (i.e., forming a film against the contours of a product mounted on a stiff backing); low stress content and good dimensional stability mean that thinner backboards can be used with no undesirable board curling. Flexible vinyl is not easy to form. The heat cycle must be controlled within 1 sec, vacuum holes must be less than 0.012 to 0.015 in. in dia, webbing develops on deep draws, and, upon release of the vacuum, the film may "tent" unless adhesion to the backing is adequate and uniform.

Mylar is produced in gages from 0.00025 to 0.0075 in. It is transparent and has good mechanical and electrical characteristics. It is difficult to form, requiring high temperatures. Adequate equipment is now becoming available to spur the use of this film. Present applications include TV tube liners, radio speaker diaphragms and skin packing.

Other materials

Ethyl cellulose ranges from transparent to opaque, and is said to have the highest available thin-section strength, maximum dimensional stability and minimum water absorption. It has low specific gravity and forms well. Taken off the market for military use, it has only recently been returned for civilian consumption. It is available in gages from 0.003 to 0.060 in. and has potential applications in displays, packaging, toys and novelties.

Nylon has been formed in experimental quantities, and indications are that it will make an excellent thin, rigid material for packaging.

Polytrifluorochloroethylene, a high temperature material, has been sheet formed for some military applications. It is extremely high priced and indications are that heating cycles will be long.

In addition to these materials, to reinforced plastics sheet, to laminates or bonded forms of different materials together, new formulations of existing materials and sheet-forming grades of entirely new materials will undoubtedly appear as sheet formed parts grow in production.

Which Forming Method?

Forming of plastics sheet is the simplest kind of manufacturing in the plastics industry. More than a dozen techniques, however, may come into play when using the basic methods. Commercial equipment is available which allows sheet forming by as many as five different methods on one machine. At the same time there are processes which cannot be performed on available commercial equipment and therefore require the design of original equipment.

One of the major reasons for the many techniques is the range of diversified products fabricated by sheet forming. All methods result in walls which are thinner than the original sheet because of the stretching inherent in the process. However, this thinning is not uniform. Some processes do make an attempt to approach this ideal, but most merely define the location of the thickest and thinnest walls. Uniform sections, deep drawing, optical clarity and other special features are usually better obtained by one process than another.

One or another of the variants of vacuum forming (as opposed to pressure, mechanical or die forming) is used for the majority of products. Until recently all forming was loosely termed "vacuum forming" but with the growth of pressure forming the terms "thermoforming" and "sheet forming" have gained common usage.

The methods described below permit some variation within themselves. Heating may be done in place, preheated sheet may be transferred to the mold, heating may be done in localized areas or on both sides of the sheet at once, etc. More important, many of these processes may be combined, in some cases on one mold and in one sequence of operation. The advantages, limitations and uses of the various methods are given in Table 3 with diagrams to illustrate each process.

Mechanical forming

Any thermoplastic sheet, properly heated, may be formed by straight mechanical action without the use of vacuum or air pressure. Sheet metal equipment —presses, benders, rollers, creasers—is used. Localized heating is used to bend angles in sheets; where several bends are required the tubular heating elements can be arranged in a pattern. After bending is completed it is neces-

TABLE 2—PROPERTIES OF

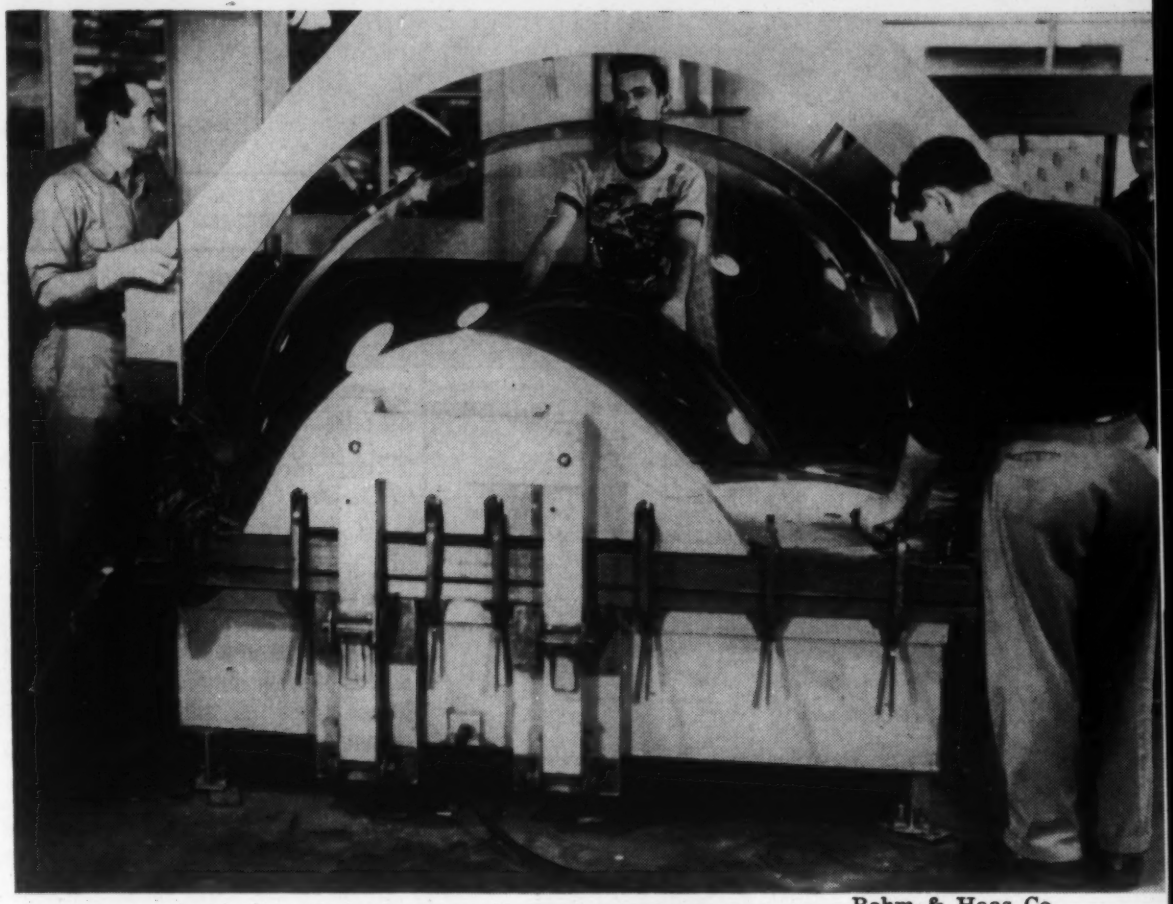
Material →		Cellulose Acetate	Cellulose Acetate Butyrate	Methyl Methacrylate	Polyvinyl Chloride	Vinyl Chloride-Acetate Copolymer
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.30	1.20	1.18	1.38	1.35
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.14	0.15	0.08	0.09	0.09
Coef of Ther Exp, 10^{-5} per °F	D696	6.0	6.0	5.0, 4.2[b]	6.2, 4.5[a]	3.8
Spec Ht, Btu/lb/°F		0.35	0.35	0.35	0.25	0.23
Refractive Index	D542	1.50	1.48	1.49	—	1.52
Water Absorption (24 hr), %	D570	4	1.5	0.3	—	0.08
Heat Distortion Temp (264 psi), F	D648	180	180	205	155, 164[a]	146
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	3.0	2.3	4.4	3.4, 4.6[a]	—
Ten Str, 1000 psi	D638	7.0	5.0	10	5.8, 8.5[a]	9.0
Elong (in 2 in.), %	D638	35	60	4	5	—
Hardness (Rockwell)	D785	R90	R90	M93	R105, R117[a]	—
Impact Str (Izod notched), ft-lb/in	D256	2	3	0.4	14, 0.7	0.4
Mod of Elast in Flex, 10^5 psi		2.2	1.7	4.5	3.5, 4.5[a]	4.5
Flex Str, 1000 psi	D790	8.5	7.2	16	11, 14[a]	14
ENVIRONMENTAL PROPERTIES						
Res to Outdoor Exposure		Low	Fair-Good	Excellent	Excellent	Fair
Chemical Resistance		Good: greases, oils, hydrocarbon solvents. Poor: strong acids, strong alkalis, ketones, esters, chlorinated solvents, alcohols	Good: greases, oils, hydrocarbon solvents, salts. Poor: strong acids, strong alkalis, alcohols, ketones, esters, chlorinated solvents	Good: alkalis, most dilute acids, aliphatic hydrocarbons, ethers, fats, mineral oils, foodstuffs. Poor: alcohols, aromatic hydrocarbons, esters, ketones, chlorinated hydrocarbons, strong oxidizing acids	Excellent: oxidizing[a] and non-oxidizing acids, alkalis, salts, alcohols, oils. Fair: hydrocarbons, chlorinated hydrocarbons. Poor: ketones, esters	Good: inorganic acids, alkalis, alcohols, aliphatic hydrocarbons, oils, fats, waxes. Poor: organic acids, aromatic hydrocarbons, ethers, many other solvents

[a]Formulated for optimum chemical resistance (Type I). [b]Biaxially oriented. [c]66 psi.

sary to hold the sheet until it cools or the plastic memory of the sheet will flatten it out again.

Free blowing and vacuum free forming

These methods do not use molds; pressure differentials alone form the sheet which is held in a clamp shaped to the base of the finished product. The sheet is otherwise "free," i.e. does not touch any other surface. Final shape is determined by the amount of pressure differential, and the success of the method is highly dependent on operator skill. The center of the sheet stretches out and thins first, resulting in thicker side walls. Both sides of the sheet are exposed to air and this provides uniform cooling. Choice between free blowing and free forming is optional, but some formers say the vacuum technique provides easier control and sealing.



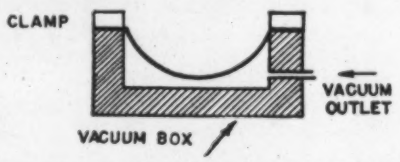
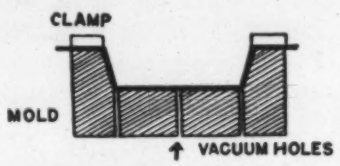
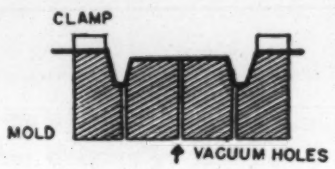
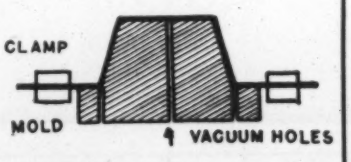
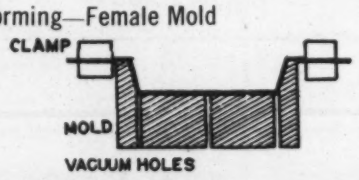
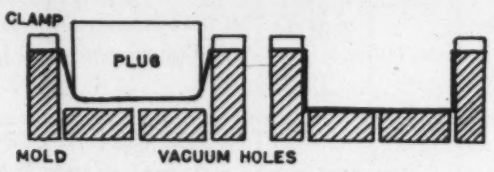
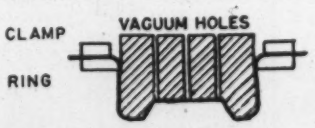
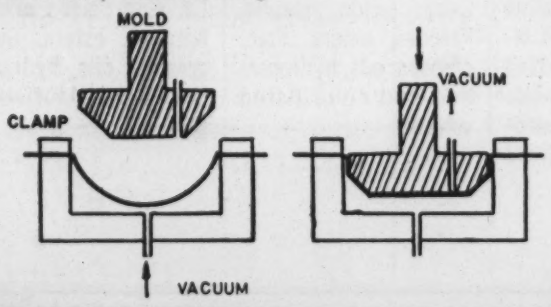
Rohm & Haas Co.

Cockpit canopy *for helicopter is example of major use of acrylic sheet and illustrates free blowing from a 5 by 7-ft sheet. Forming takes about 15 min.*

RIGID THERMOPLASTIC SHEET

	Straight Polystyrene	Modified Styrenes	ABS Terpolymer	Oriented Polystyrene	Lower Density Polyethylene	Higher Density Polyethylene
	1.05	1.05	1.01	1.06	0.92	0.96
	0.07	0.07	0.11	—	0.18	0.19
	3.8	4.2	5.6	4.0	9.0	9.0
	0.34	0.10	0.38	0.32	0.55	0.55
	—	—	—	1.59	1.51	1.51
	0.04	0.3	—	0.05	0.01	0.01
	170	176	183	—	—	170[c]
	5	3.3	1.96	4.6	0.2	1.5
	7	3.3	4.7	10	1.3	4.4
	2.0	24	70	7	200	100
	M74	M30	R85	M90	R11	R40
	0.30	4.8	7.0	3	No Break	3.0
	5	4.0	1.84	—	—	1.4
	12	6.0	6.8	10	—	—
	Low Good: alkalis, salts, lower alcohols, glycols, water. Fair: mineral and vegetable oils. Soluble in aromatic and chlorinated hydrocarbons. Softened or attacked by higher alcohols, gasoline, strong oxidizing acids, chlorine and bromine waters	Low Good: alkalis, salts, dilute mineral acids, lower alcohols. Poor: higher alcohols, gasolines, ketones, glacial acetic acid, oxidizing acids, unsaturated hydrocarbons, essential oils, aromatic and chlorinated hydrocarbons, esters, ethers	Low Good: alkalis, dilute inorganic acids, organic acids, alcohols. Poor: unsaturated hydrocarbons, ketones, ethers, acetates, chlorinated solvents, nitrohydrocarbons, concentrated mineral acids	Fair-Good Good: weak acids, some strong acids, alkalis, alcohols. Poor: oxidizing acids, esters, aromatic and chlorinated hydrocarbons, some aliphatic hydrocarbons	Fair Good: acids, alkalis, ketones, esters. Fair: greases, oils, hydrocarbon and chlorinated solvents	Good Excellent: acids, alkalis, ketones, esters. Good: greases, oils, hydrocarbon and chlorinated solvents

TABLE 3—SHEET FORMING METHODS

Method ↓	Advantages	Limitations	Type of Use
Mechanical Forming ▬ = SHEET 	Simple, inexpensive, quick, uses existing equipment	Heavy mark-off; long bends (usually over 2 ft) tend to bow	Simple bends; tube beading
Free Blowing and Vacuum Free Forming 	Simple, inexpensive, no mark-off (esp advantageous for optical clarity)	Center of sheet becomes quite thin; part shape and strength dependent on operator's skill	Simple parts (generally fish-bowl shape) with wide dimensional allowances
Vacuum Forming —Female Mold 	Easiest of the mold methods; can be done on straight vacuum or combination forming machines; good registration in clamping frame and even pull for preprinted sheet	Since deep drawing thins sheet excessively, requires fairly simple design	Low-profile parts; parts with profile design or embossing on mold side of sheet
Vacuum Forming —Male Mold 	Thickest section is on top, rather than side walls; accurate registration	Material waste high because sheet must be drawn down enough to prevent excess side wall thinning at base	Low-profile parts requiring heavy top section; principle is used in sections of combination mold
Drape Vacuum Forming —Male Mold 	Male mold costs lower than female; forming and release easy; provides high quality deep draws; exposed area of side away from mold means easier cooling, has no mark-off	Part somewhat thinner toward mold bottom; best for thin sheets	Every sheet material has been formed this way, esp styrene copolymer; parts requiring fairly deep draw and good surface on one side
Drape Vacuum Forming—Female Mold 	Prevents lockup of such plastics as flexible vinyl and polyethylene, thus insuring uniform heating and forming; provides stripping action from mold	May cause mark-off on exterior side	Flexible vinyl; polyethylene; heavy plastics
Vacuum Forming with Plug Assist—Female Mold 	Allows deeper drawing than other methods; mold runs cooler, decreasing cooling cycle; close tolerances	Requires extremely close control of both sheet and plug temperature; complex equipment, costly molds	Deep drawn parts requiring dimensional accuracy
Forming with Plug and Ring 	Simple equipment; high pressure for tough sheets	Thin side walls, heavy mark-off	Simple, shallow draws of tough sheets
Mechanical Forming with Slip Ring 	Allows more uniform distribution of material	Simple shapes, no recesses	Deeper draws than above of tough sheets
Vacuum Snap-Back Forming 	Strong parts; omitting second vacuum operation results in part with little mark-off	Special equipment required	Strong parts with uniform walls; second vacuum operation allows complex parts with recesses

Note: Sketches adapted with permission from Butzko, Robert L., "Plastic Sheet Forming," Reinhold Publishing Corp., 1958.

Typical Products
Instrument panels; display board parts
Aircraft and boat canopies; skylights
Floor mats; displays
Three-dimensional maps
Refrigerator doors and parts; other appliances
Auto door liners; displays; packaging
Electronic flash gun
Photographic trays
Instrument enclosures
Aircraft domes

continued on p 132

Vacuum forming

Female mold—The heated sheet is pulled into the mold by vacuum alone; it may be clamped above the mold or directly to it. The side against the mold picks up the full impression within the limits of the sheet thickness. Evacuation must occur quickly enough to prevent cooling during the draw, and the number and location of vacuum holes are determined by this consideration. In addition, vacuum holes must be placed in the mold recesses to provide clean pull-down of the sheet.

Deep drawing thins the sheet excessively in most cases. Straight vacuum forming is therefore limited to parts of low profile—generally where the depth is less than half the diameter of any opening.

Male mold—The sheet is pulled down by vacuum over a male mold placed in a cavity, forming a stronger part because the thickest section is on the top, but still limited to low-profile parts because of excessive thinning of the lower side walls. A variation of this method is to apply vacuum before heating the sheet, thus achieving greater accuracy of registration.

Drape vacuum forming

Male mold—The sheet is mechanically pulled down or draped over the male form until it is level with the lowest height of the mold. After the sheet is sealed to the edges of the mold, vacuum draws it to the mold contours, which may include female sections. Close control of the prestretching allows accurate forming of predecorated sheets.

Because of the mechanical draping action, fewer vacuum holes are required. The male mold is usually mounted on a molding base over a large hole. Bottom edge venting is accomplished by spacing the mold 0.010 to 0.015 in. above the base.

This is the most popular forming method at the present time, permitting a 1:1 ratio of depth to diameter for most materials and 1½:1 for such deep drawing sheet as calendered vinyl. The heaviest sections occur at the top, the sheet thinning out somewhat toward the bottom of the mold.

Female mold—Plastics such as flexible vinyl and polyethylene sag heavily when heated. They can therefore be heated at some distance above the mold and then lowered to drape into the female mold and over the edges to seal off the mold, vacuum then being applied in the conventional manner.

Vacuum forming with plug assist—female mold

A male plug forces the heated sheet down into the female mold, then vacuum is applied. If the plug is cold it locks the material and prevents excess thinning at the bottom of the part, although the walls are thinned to some extent. In this case the plug is usually wooden and the parts do not have accurate side walls or bottoms.

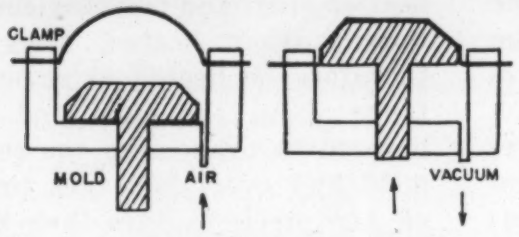
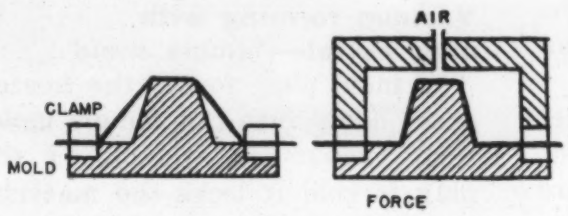
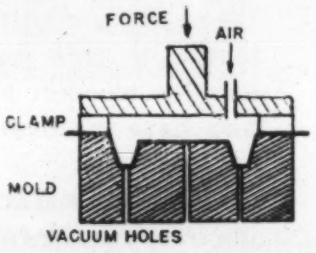
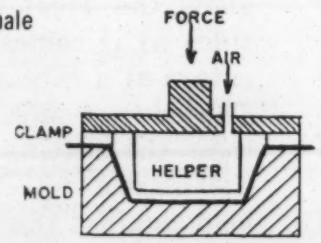
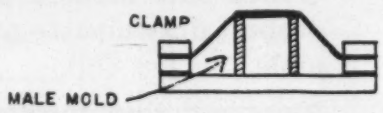
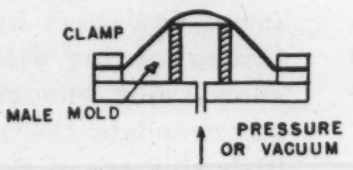
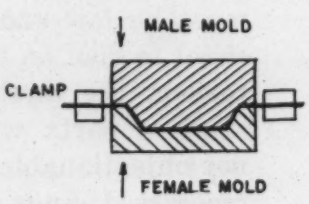
For deeper drawn parts requiring more uniform distribution of the plastic, the plug is heated to allow the sheet to slip along its sides as it comes down. The plug enters at a rate as high as 30 ips. The plug temperature is higher than the setting temperature of the plastics sheet which must be held against the mold by vacuum as it cools. When accurately controlled this method produces the deepest drawn parts presently possible.

Plug and ring forming

Mechanical—Using neither vacuum nor air pressure, this method forms the sheet by stretching it through a ring with a plug which allows only enough clearance to accommodate the sheet. There is little slippage of material over the plug because the plug temperature must be low enough to allow the sheet to cool on the plug. For this reason, the method is limited to shallow parts where mark-off is not objectionable and there are no recesses. It finds major application with heavy or tough materials.

Vacuum—When a part having recesses is formed by plug and ring, vacuum can be pulled by holes in the plug in order to draw the sheet into the recesses. Al-

TABLE 3 (continued)—SHEET FORMING METHODS

Method ↓	Advantages	Limitations	Type of Use
Pressure Snap-Back Forming 	Deep drawn parts; mold runs slightly cooler	Expensive setup; requires up-drape machine	Strong, complex parts of great depth
Blow Back Forming with Pressure 	Deep drawn parts of heavy, tough materials; permits forming materials too heavy for vacuum forming	Commercial equipment not generally available at present	Parts made of tough materials and having high dimensional accuracy and close detail
Pressure Forming —Female Mold 	Allows forming of tougher materials than vacuum forming in female mold; good dimensional tolerances	Depth of draw limited; equipment costly; molds must be highly polished	Low-profile parts of tough materials requiring close tolerances, accurate embossing, lettering
Pressure Forming—Female Mold with Helper 	Prestretching by helper allows deeper drawing	Equipment costly; molds must be highly polished; some mark-off will occur	Deep drawn, high-profile parts of tough materials and with good dimensional accuracy
Ridge Forming 	Low cost; simple; parts with little mark-off	Design extremely limited	Simple parts requiring good surface or optical clarity
Ridge Forming with Vacuum or Air Pressure 	Low cost; parts with little mark-off	Design limited; results depend on operator skill	Simple parts with excellent surface and optical clarity
Mold Forming—Male and Female Dies 	Accurate parts (may require simultaneous cutting or punching along with forming)	Little depth of draw; heavy mark-off; shapes limited	Low-profile parts of opaque materials
Grease Forming	Allows forming heavy-gage parts which must contact mold surface and yet have no mark-off	Slow and costly	Parts of highest possible quality

Typical Products
Aircraft domes
Contour maps
Display signs
Portable power pack
Equipment housings
Decorative acrylic parts
Small boxes and containers
Aircraft domes and noses

though more complex shapes are possible, the depth of draw is still limited.

Mechanical forming with slip ring

The basic principle here is that the ring through which the sheet is forced allows the sheet to slip enough to produce parts with thicker walls. Various types of clamps are used and, in addition, the clamps may be heated and/or lubricated.

Snap-back forming

Vacuum—The first step of this technique is vacuum free forming. The male plug or mold is then pushed down into the cavity and sealed on the edge of the sheet. The vacuum is released and pulled through holes in the male mold to draw the sheet up tight to the male mold.

Pressure—This is a variation of the above, using free *blowing* as the first step and then pushing the male mold *up*.

Blow-back forming with pressure—male mold

This technique is essentially drape forming, but pressure rather than vacuum is used to fit the sheet against the contours of the mold. The sheet is draped loosely over the mold and a pressure head moves down over it. Air pressure flattens the sheet to the mold; vent holes in the mold allow air trapped beneath the sheet to escape.

Some Process Details

Preprinting the sheet

Sheet which is purchased plain may be printed upon by any common method prior to forming and yet attain high detail and accuracy. Preprinting may be a multicolor process and methods used include: silk screen, lithography, rotogravure, offset, letterpress, spray painting and decalcomania. Hot stamping, hot stylus marking and embossing are also used. By far the most widely used of all methods is the silk process, which generally proves the least expensive.

In order that the formed pattern be correct, the flat sheet must usually be printed in distortion. The printed pattern may be determined in either of two ways: 1) "shrink-back," usually used when close registration is not required, where the formed part is hand painted and then reheated until it flattens out and yields a distorted pattern which can be copied, 2) "calibrated grid," where the flat sheet is ruled with a ¼-in. grid and then formed to obtain a distorter grid which is used to calibrate the necessary artwork distortion.

Inks must be selected according to their compatibility with the material and printing method; therefore ink manufacturers should be consulted. For embossing and stylus marking a full range of papers and foils is also available.

Heating the sheet

Accuracy of the final part depends upon proper heating techniques. Sheet formed below the optimum temperature — usually between 285 and 325 F—allows faster production but may result in stressed parts. On the other hand, overheating damages the finish. Most sheet can be heated to forming temperature in 20 to 55 sec. Very heavy gages may require 1 to 5 min. Heating equipment includes: Infra-red and Far infra-red heaters, electrical Cal-Rod units, Nichrome wire elements, gas ovens, and hot air guns for spot heating.

Trimming or postforming

Trimming of short-run parts is usually done by cutting with bandsaw or router and finishing with a belt sander. Punch-press stamping with a clicker-type steel die is common for large production runs. Techniques are being developed for operating a steel die with the mold or incorporating the die into the mold. Undercuts and beads are accomplished by spot heating and local forming. Thin-gage materials are often crimped back around an entire edge.

Female mold with helper—In this variation of the process described above, a helper (or male plug) is mounted on the pressure plate. The sheet is preheated and clamped in place. The plug draws material from the side walls into the bottom of the cavity, thus reducing the thinning action and allowing deeper draws. Air pressure is then introduced in the conventional manner.

Ridge forming

Mechanical—This process may be used for some simple parts. A partial mold is pushed into a clamped, heated sheet. Both the area contacted and the stretched portion are in the final part.

Vacuum or air pressure—In this variation a section of the ridge is sealed off and free blown or free formed.

Mold forming—male and female dies

Conventional molding of heated sheet between male and female dies in a press is used for certain parts. The molds must be heated. There is little slipping action of the sheet and therefore the depth of draw is limited.

Pressure forming

Female mold—Pressure as high as 300 psi may be used to force the sheet down into the female mold, so a hydraulic press is used to clamp the mold against the pressure plate. The sheet may be heated before transfer to the press or the clamp may incorporate the heater. Air pressure is applied through holes in the pressure plate. Molds are usually metal but epoxy resin molds have been successfully used.

Grease forming

Grease, applied to the male mold, becomes fluid under heat and lubricates the sheet. To insure saturation, the mold may be

Some Mold Considerations

Male vs female

The choice of male or female mold depends upon design, time available and cost factors. Male-mold parts are usually stronger because the draping action allows heavier walls at the top; the bottom can be reinforced by crimping. Multiple-cavity molds are generally female because they use less material.

Male molds are used to: 1) obtain sharp surface detail on inside of part, 2) lower mold cost by making them in sections, 3) employ drape or snap-back forming, or 4) save time in producing prototypes.

Female molds are used when: 1) sharp detail is needed on outside of part, 2) high surface finish is desired (usually polished metal mold), 3) heavy wall section is required at start of draw, 4) design allows low cost female mold, or 5) exact model is available.

Materials

For short runs, wood and plaster are common. On short and medium runs, cast phenolic and epoxy resin molds work satisfactorily. Long runs usually require a metal mold, either ferrous or nonferrous.

The high thermal conductivity of metal molds is advantageous in controlling the temperature, but this advantage must be balanced against mold cost. Aluminum is the most widely used metal.

Following is a brief description of mold materials:

1. Wood—Use of hardwood for experimental or short runs is sound. Caution should be exercised in type of adhesive used for joining sections as it may react with sheet material. For improved surface finish and wear resistance, wooden molds can be coated with an epoxy resin, then sanded, buffed and polished.

2. Plaster — A low-cost, easily worked material which sets at room temperature and does not require extensive heating apparatus.

3. Plastic—Cast phenolic, cast filled epoxy and furane resins have the same general advantages, i.e., excellent dimensional stability, good abrasion resistance and a smooth, nonporous surface. Plastics molds may be prepared and patched at little expense. The mold bottom may be reinforced with resin-impregnated fiberglass.

4. Aluminum—In addition to being easily machined, aluminum is a good heat conductor, which is an advantage when cooling the formed piece. Patternmakers are familiar with it and shrink rules are readily available.

5. Sprayed metal—Sprayed metal molds are classified as permanent. Metals and wires which have been sprayed include aluminum, copper, nickel, low carbon steel, tin and zinc. As many as 500,000 pieces have been formed with no evidence of deterioration. Minute detail can be reproduced.

6. Electroformed — Permanent molds can be produced by building up electroformed layers of copper, nickel and chromium into a shell. Precise detail and exceptional surface finish may be obtained through controlled plating techniques. The shell may be backed with zinc or other low temperature nonferrous alloys.

7. Machined—For simple shapes, molds machined of standard steel stock are satisfactory from both an economic and production point of view. However, on multi-cavity molds, the trend is toward cast materials because of more favorable cost.

Design

Two basic factors in mold design are shrinkage allowance and vacuum-port size and location. Molds must be designed to allow for shrinkage of the thermoplastic sheet; in addition, aluminum molds require a 0.125 in. per ft allowance. Sheet shrinkage is less critical in drape forming because of the rigid core. After-mold shrinkage and normal thermal shrinkage are usually insignificant.

The size and number of vacuum holes are determined by both the thermoplastic sheet and the part geometry. Thin-gage materials usually require hole diameters of 0.025 to 0.045 in. Materials thicker than 0.040 usually require a maximum hole diameter of 0.060 in. The number of holes should allow evacuation in less than ½ sec except for blister or contour packaging where controlled exhaust is used.

covered with a felt blanket. The mold is pressed up into the sheet which cools on the mold. After removal, the sheet is cleaned with kerosene, white gasoline or other solutions. Female molds for use with vacuum or air pressure may also be greased.

Other techniques

In addition to combining techniques in new and advantageous ways, sheet formers will undoubtedly develop entirely new techniques with the increased production of newer materials and, particularly, sheet forming equipment and machines. Some techniques already gaining acceptance include: shading the sheet during heating to provide more heat in areas that tend to remain thicker during forming, thus obtaining more uniform walls; heated clamping frames to reduce the cooling effect on the outside of the sheet; and using water coils in the mold to accurately control temperature. One recently developed method uses a cold mold and jets of air blown from a hot plug to force the heated sheet to stretch into the general shape of the mold before evacuation. The process produces highly uniform walls and relatively small corner radii.

Chicago Molded Products Corp.

Display package *was made by straight mechanical forming. The design was silk-screened in gold on clear acetate sheet which was then formed into a tube by beading top and bottom edges and cementing vertical joint.*

Dow Chemical Co.

Tunnel and speedboat *were economically produced as sheet formed parts. Sheet for tunnel was preprinted.*

Dow Chemical Co.

Bowls and trays *were vacuum formed from styrene copolymer sheets of various colors.*

What Are the Design Limitations?

Sheet forming allows wide latitude in design, Deep draws, fine details, undercuts, mechanical inserts and close tolerances are all possible. However, certain basic considerations generally apply to any design:

Sheet thickness—Approximate sheet thickness is determined by multiplying the average thickness desired by the total of all areas in the formed part and then dividing by the area of the flat sheet within the clamp. In most cases this figure is increased by a safety margin.

Depth of draw—Only generalized rules can be stated for determining depth of draw because it depends highly on the material formulation. For straight forming into a female cavity, the depth is usually one-half the width of the cavity. For drape forming 1:1 is considered acceptable. With plug assist forming the 1:1 ratio has been exceeded.

Fillets—Adequate fillet radii must be used to provide maximum strength. Radii should be at least equal to the wall thickness of the sheet, never less than 1/32 in. (1/8 in. is often the specified minimum).

Draft—For a female-molded part, ½ deg of draft is often satisfactory because the material will shrink away from the mold. Male-molded parts, where the material tends to cling to the male plug, require drafts of from 1 to 2 deg.

Ribbing—Ribs can be placed to add rigidity to the part as well as to enhance the design itself. With proper ribbing, thin-gage sheet can be used successfully for a broad range of practical applications, thus leading to a reduction in materials cost as well as a reduction in heating cycle time.

Undercuts—No design limitations can be given for the depths of undercuts, as the type and design of mold can generally be adapted to the desired undercut, or the undercut can be machined into the part after forming. Mold design is adapted in this way: 1) deep undercuts are accomplished with side cores actuated by hand or air cylinders, 2) moderate undercuts are made with sliding or spring-loaded and hinged cores, 3) smaller undercuts such as beads and snap ring grooves are formed by vacuum or air pressure alone, the part being flexed off the mold while still warm and pliable.

Inserts—A recent development in vacuum forming involves permanent or "orphan" inserts that are molded into the part. The insert—wood or some material close to the sheet in thermal coefficient

Rohm & Haas Co.

Skylights *were made by sheet forming.*

of expansion—is placed on the mold and the plastic drawn around it. When the mold is stripped, the insert stays with the part. Not only does the insert add the necessary flange or undercut, but it also adds stiffness to the piece.

In planning a permanent insert it is important to remember that the coefficient of expansion of the plastic is several times greater than that of metal. The design must make allowances for this major difference. In some cases a non-rigid metal insert may be used; in other cases the design may permit a certain amount of movement in the insert.

B o s s e s — Mounting bosses should be cemented into place after the part is formed. Recently developed adhesives provide adequate strength for such parts.

Light transmission—Parts with interior illumination may show color variance due to thinning at corners. Such parts should maintain flowing lines, large fillets and simple design.

Shape—The closer the shape of each male or female section of a sheet formed part is to the free formed shape, the more uniform will be the wall thickness and the stronger the part.

Preprinted—Parts formed from preprinted sheet are most accurate if the part is so designed that: 1) a male mold can be used, 2) the sheet will be drawn only far enough to pull a vacuum, 3) small blanks, preferably less than 21 by 21 in., can be used, 4) draws are shallow as possible unless artwork is an overall pattern.

Rohm & Haas Co.

Outdoor display sign, *40 ft wide, was made from prepainted acrylic sheet.*

Acknowledgments

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Auburn Plastics, Inc.
Bakelite Co., Div. of Union Carbide Corp.
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Celanese Corp. of America
Chicago Molded Products Corp., Campo Div.
Dow Chemical Co.
E. I. du Pont de Nemours & Co., Inc.
B. F. Goodrich Co.
W. R. Grace & Co., Polymer Chemicals Div.
Minnesota Mining & Mfg. Co.
Monsanto Chemical Co.
Plax Corp.
Phillips Chemical Co.
Rohm & Haas Co.
St. Regis Paper Co., Panelyte Div.
Seiberling Rubber Co.

References

Information on forming methods was drawn to a considerable degree from Butzko, R. L., *Plastic Sheet Forming*, Reinhold Publishing Corp., New York, 1958. Other references:

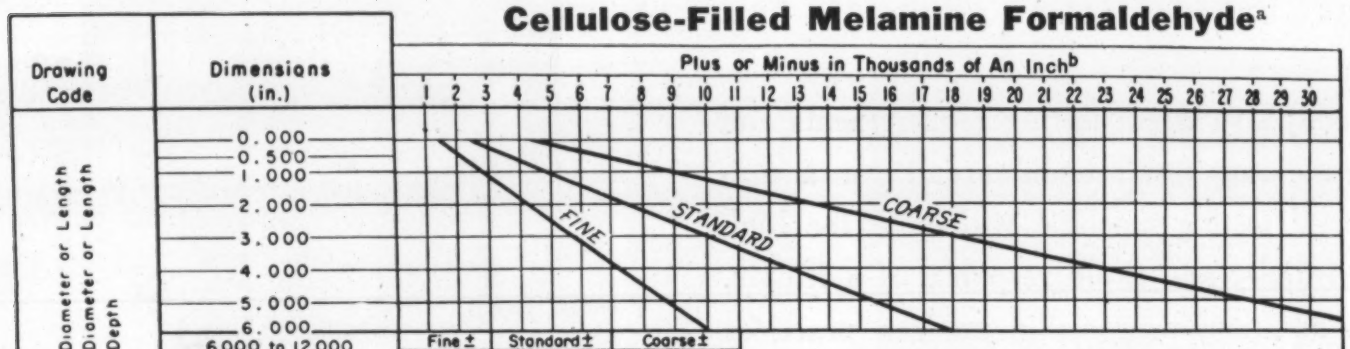
Campbell, J. B., "Many Parts Made From Thermoplastic Sheet," MATERIALS & METHODS, Mar '55, p 99.

Plastic Sheet Forming, Rpt. No. 12, American Management Assn., Inc., Packaging Div.

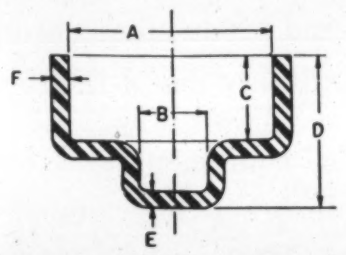
Reprints of this Manual are available at 35¢ each until supply is exhausted. See page 170 for complete list of available Manuals. Write for quotations on quantities of 100 or more. Address Reader Service Dept., MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*

Recommended Design Tolerances for Plastics Moldings

Cellulose-Filled Melamine Formaldehyde[a]



Drawing Code	Dimensions (in.)	Fine ±	Standard ±	Coarse ±
A = Diameter or Length B = Diameter or Length C = Depth	6.000 to 12.000 For each inch over 6.000 add (in.)	0.002	0.003	0.006
	Over 12.000 For each inch over 12.000 add (in.)	0.004	0.006	0.007
HEIGHT D	Single Cavity 0.000-1.000	0.004	0.006	0.007
	Multiple Cavity 0.000-1.000	0.0045	0.007	0.0095
	For each inch over 1.000 add (in.)	0.0035	0.006	0.008
BOTTOM WALL E	0.000 to 0.100	0.004	0.005	0.007
	0.100 to 0.200	0.005	0.006	0.008
	0.200 to 0.300	0.005	0.006	0.008
SIDEWALL F DIMENSION [c]		Section thickness to be held relatively constant		
F Variation in wall thickness due to eccentricity, 0.005-0.007 in. Interlocking reduces this.				
DRAFT ALLOWANCE		1/4°	1/2°	1°



[a] Tolerances shown are approximate and apply only where service temperatures for molded part will not exceed 120 F.

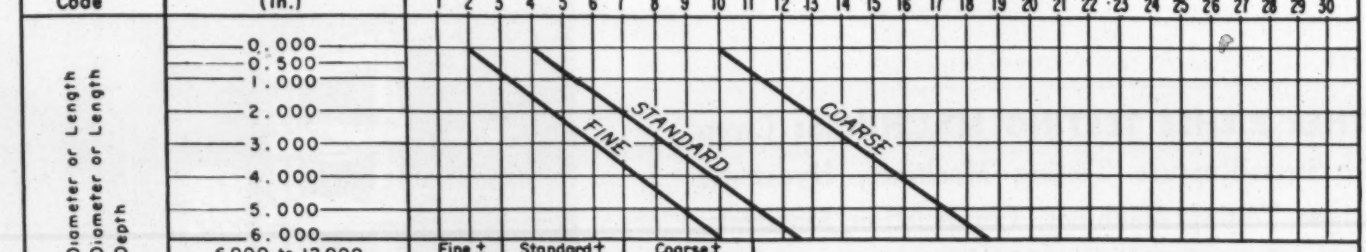
[b] These tolerances do not apply to screw threads, gear teeth or fit of mating parts; dimensions in these classifications can generally be held to closer limits. These tolerances do not include allowance for aging characteristics of material.

[c] For further information see discussion in Plastics Engineering Handbook.

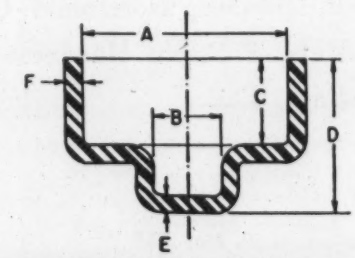
DWG. CODE			
D, E	Compression molded. For projected area over 20 sq in.	Fine	Add 0.002 in. for each add'l 10 sq in.
		Standard	Add 0.003 in. for each add'l 10 sq in.
		Coarse	Add 0.005 in. for each add'l 10 sq in.

		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (F = Fine; S = Standard; C = Coarse) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
	Transfer, jet, or injection molded. Any area	
D	Single cavity	F S C
D	Multiple cavity	F S C
D	For each inch of depth over 1.000 add (in.)	0.002

Cotton Rag-Filled Melamine Formaldehyde[a]



Drawing Code	Dimensions (in.)	Fine ±	Standard ±	Coarse ±
A = Diameter or Length B = Diameter or Length C = Depth	6.000 to 12.000 For each inch over 6.000 add (in.)	0.002	0.0025	0.003
	Over 12.000 For each inch over 12.000 add (in.)	0.0025	0.004	0.006
HEIGHT D	Single Cavity 0.000-1.000	0.006	0.008	0.012
	Multiple Cavity 0.000-1.000	0.008	0.010	0.014
	For each inch over 1.000 add (in.)	0.002	0.004	0.005
BOTTOM WALL E	0.000 to 0.100	0.004	0.006	0.009
	0.100 to 0.200	0.004	0.006	0.009
	0.200 to 0.300	0.004	0.006	0.009
SIDEWALL F DIMENSION [c]		Section thickness to be held relatively constant		
F Variation in wall thickness due to eccentricity, 0.005-0.007 in. Interlocking reduces this.				
DRAFT ALLOWANCE		1/8°	1/4°	1°



[a] Tolerances shown are approximate and apply only where service temperatures for molded part will not exceed 120 F.

[b] These tolerances do not apply to screw threads, gear teeth or fit of mating parts; dimensions in these classifications can generally be held to closer limits. These tolerances do not include allowance for aging characteristics of material.

[c] For further information see discussion in Plastics Engineering Handbook.

DWG. CODE			
D, E	Compression molded. For projected area over 20 sq in.	Fine	Add 0.001 in. for each add'l 10 sq in.
		Standard	Add 0.002 in. for each add'l 10 sq in.
		Coarse	Add 0.003 in. for each add'l 10 sq in.

		PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (F = Fine; S = Standard; C = Coarse) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
	Transfer, jet, or injection molded. Any area	
D	Single cavity	F S C
D	Multiple cavity	F S C
D	For each inch of depth over 1.000 add (in.)	0.0015

Source: *Plastics Engineering Handbook* of the Society of the Plastics Industry, Inc., Reinhold Publishing Corp., 1954.

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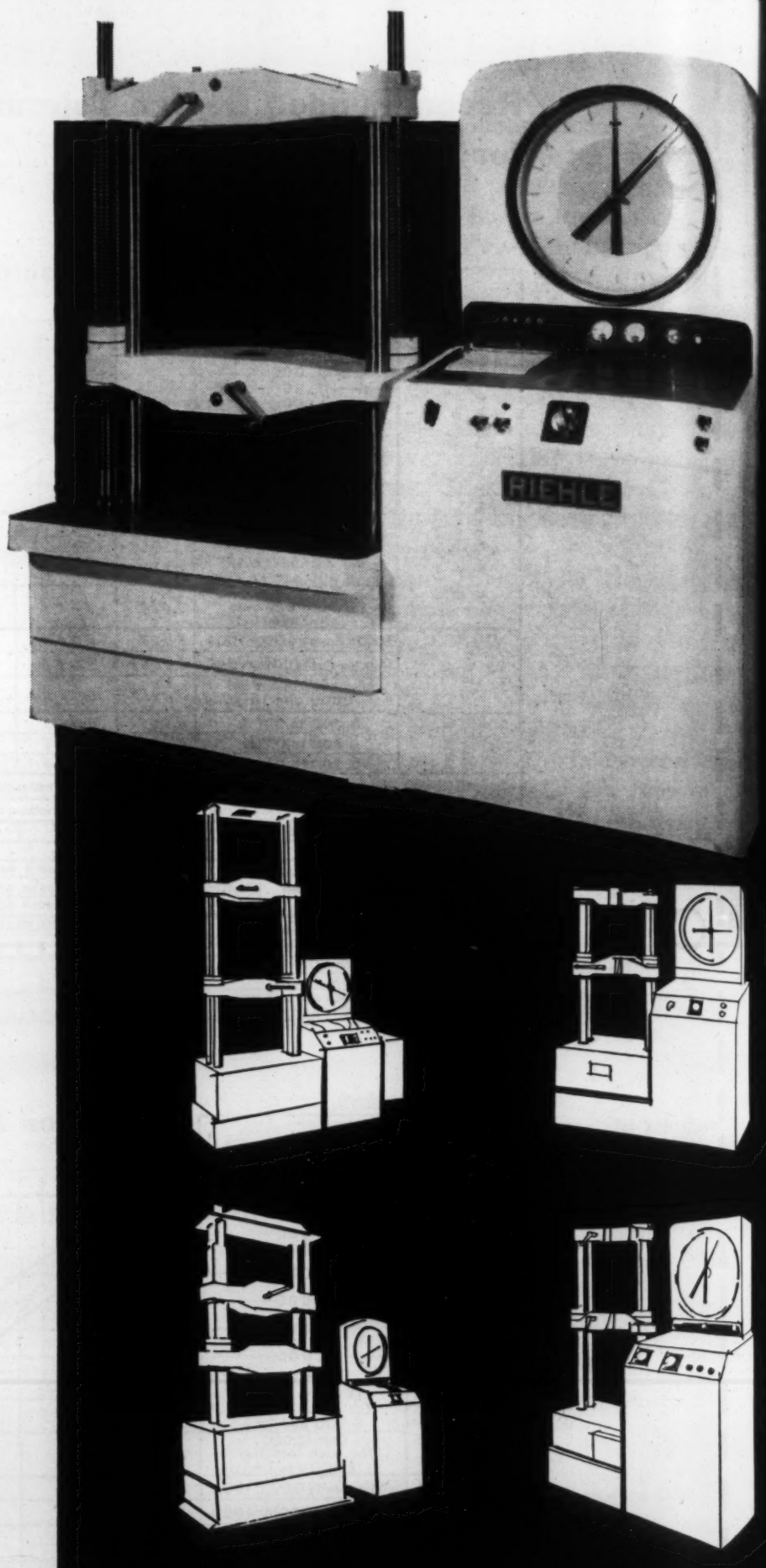

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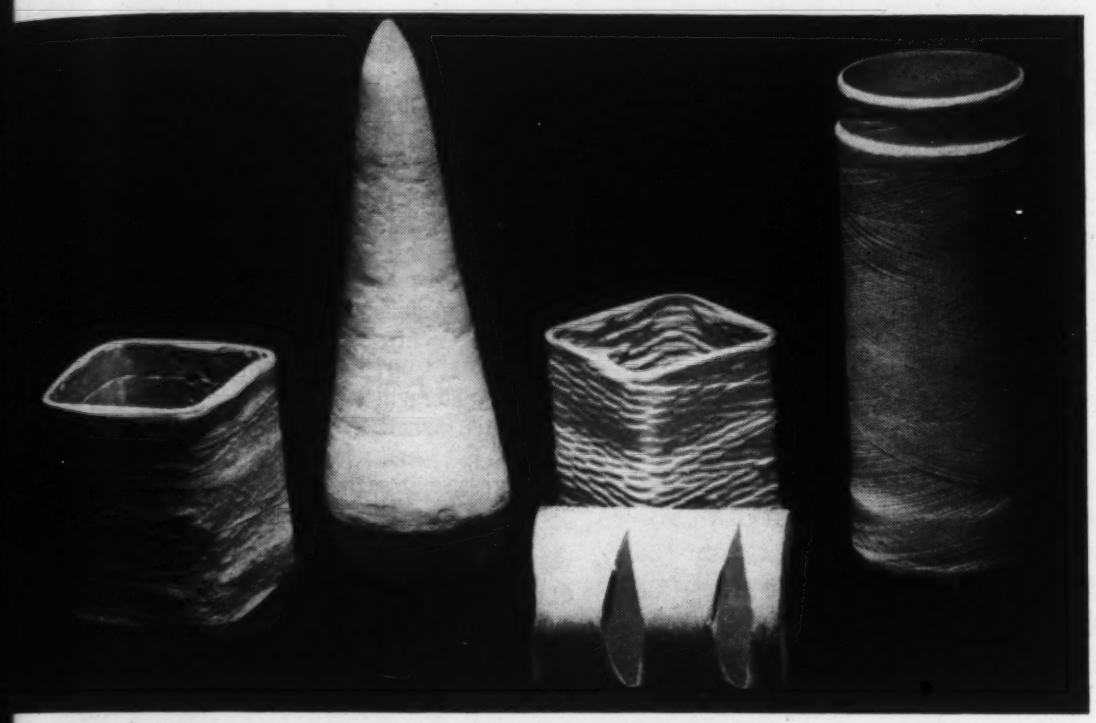
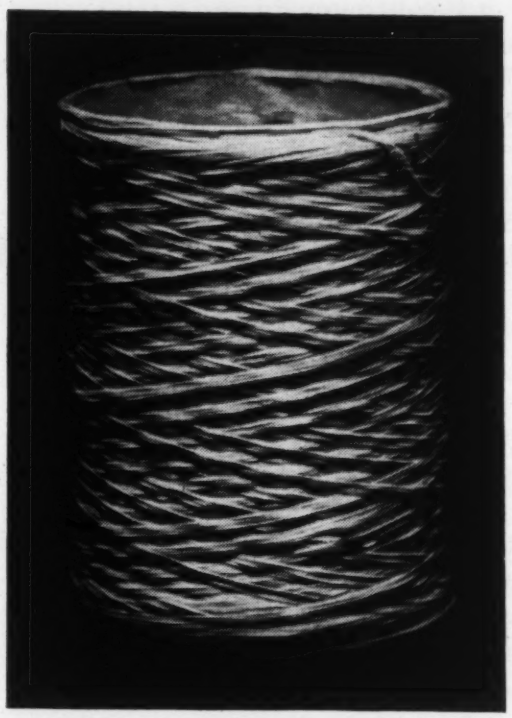


Typical ceramic shapes *made by filament winding.*



Close-up *of filament-wound shape.*

Filament winding technique turns out . . .

Non-Brittle Ceramic Shapes with Good Thermal Properties

■ Fabrication of large, relatively non-brittle ceramic shapes with extremely good strength-weight ratios and good resistance to thermal shock is now possible with a newly developed technique.

According to the developer, Horizons, Inc., 2891 E. 79th St., Cleveland 4, Ohio, filament winding, long used to produce reinforced plastics shapes, lends itself well to the fabrication of large ceramic shapes. For instance, the developer says entire missiles and 9 or 10-ft high radomes possibly can be fabricated in one piece by using the process.

How technique works

Still under development, the technique uses fibers that are coated with a ceramic colloid (composition of which has not been revealed) and wound on a mandrel. After filament winding the part is heat treated at a temperature of about 1000 F. Horizons says shrinkage of the part is negligible since no extremely high temperature firing is required.

Parts turned out by the process (see photo) are said to have high thermal insulating values and good resistance to oxidation. Heat resistance of the filament-wound ceramic shapes is dependent on the type of fiber used although characteristics of the bonding agents allow the completed parts to be used at temperatures somewhat above those practical for the fiber alone. Horizons is currently using commercial glass fibers that withstand temperatures up to 1200 F.

The ceramic shapes are not impervious to moisture but can be made moisture resistant by coating, according to Horizons.

PROPERTIES OF FILAMENT-WOUND CERAMIC SHAPES[a]

Specific Gravity	1.5–2.2
Flexural Strength, psi	10,000–23,000
Max Continuous Use Temperature, F	1000–1200
Modulus of Elasticity, psi	10^6
Dielectric Strength, v/mil	450

[a]Values obtained on a two-way wrapped solid round bar.

Polyester Resin Withstands 500 F Continuously

■ Commercial production has begun on what is claimed to be the most heat resistant polyester plastic yet developed. The plastic, a triallyl cyanurate polyester, is said to withstand a temperature of 500 F continuously and a temperature of 1000 F intermittently. Designated Vibrin 136A, the polyester resin is also said to have excellent dielectric properties and a radar transparency approximately ten times better than conventional polyesters.

The polyester plastic is a product of Naugatuck Chemical Div., U. S. Rubber Co., 1230 Avenue of the Americas, New York 20. It was developed in cooperation with Boeing Airplane Co. According to Naugatuck, the plastic should be ideal for radomes and nose cone housings for radar equipment on manned aircraft, and on rockets and missiles.

Properties

Robert G. Nelb, manager of Vibrin research and development for Naugatuck, says Vibrin 136A resin produces a craze-free laminated part that can be fully postcured without delamination. As a result it is possible to produce high temperatures resistant laminates having low (0.3%) water absorption, 50 to 100% improved mechanical properties at high temperatures, and excellent electrical properties even under very humid conditions.

Nelb says data on the electrical properties of the resin are not complete but the date available (see accompanying table) suggest the resin has excellent electrical characteristics. He says radomes fabricated from the resin have surpassed all electrical tests and withstood any heat generated by the absorption of electrical energy with virtually no deterioration.

Vibrin 135

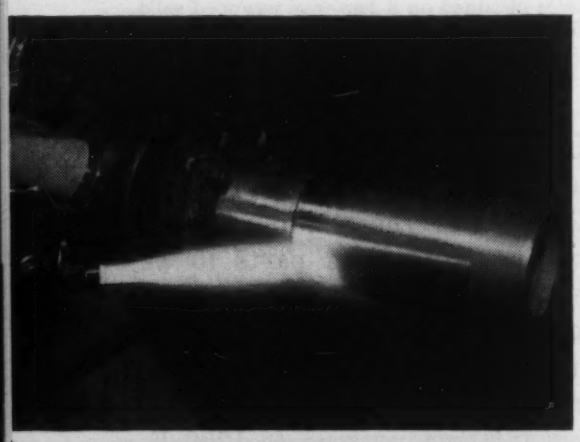
Naugatuck has developed another heat resistant polyester designated Vibrin 135. It is described as a maleic anhydride-modified polyester resin with triallyl cyanurate as the monomer. Vibrin 135 and an experimental version of Vibrin 136A were previously discussed in this magazine (M/DE, Apr '58, p 204).

Much of the research work in developing the new polyester resins was sponsored by Wright Air Development Center.

PROPERTIES OF VIBRIN 136A

ORIGINAL MECHANICAL PROPERTIES[a]	
Flexural Strength, psi	67,500
Flexural Modulus, psi x 10^{-6}	3.5
Tensile Strength, psi	55,000
Compressive Strength, psi	50,000
PROPERTIES AFTER AGING[a]	
Flexural Strength, psi	
Water Immersion (30 days)	62,500
500 F (½ hr)	40,000
500 F (192 hr)	40,000
500 F (500 hr)	43,000
500 F (1000 hr)	31,000
500 F (2000 hr)	12,000
600 F (½ hr)	22,000
700 F (½ hr)	11,000
Flexural Modulus, 10^{-6} psi	
500 F (½ hr)	2.6
500 F (192 hr)	2.4
Tensile Strength, psi	
Water Immersion (30 days)	50,000
500 F (½ hr)	40,000
Compressive Strength, psi	
Water Immersion (30 days)	45,000
500 F (½ hr)	30,000
ELECTRICAL PROPERTIES[b]	
Dielectric Constant	
Dry (1 mc)	4.09
Dry (9375 mc)	4.23
Wet (1 mc)	4.05
Wet (9375 mc)	4.07
Loss Tangent (9375 mc)	
Dry	0.0039
Wet	0.0039

[a] Values obtained on a 12-ply 181-Garan laminate with a resin content of 38%.
[b] Values obtained on a 60-ply 181-Garan laminate 0.6 in. thick.



Applying carbide coating *to a metal sleeve with a thermal powder spray gun. The resultant coating is said to withstand the severe abrasion of foundry sand.*

Two Tungsten Carbide Powders Produce Nonporous Coatings

■ Two tungsten carbide powders have been developed that, when sprayed on metals, produce smooth, nonporous deposits containing up to 80% carbide.

The powders, called Thermo-Spray 32-C and 31-C and developed by Metallizing Engineering Co., Inc., 1175 Prospect Ave., Westbury, N. Y., are contained in a chromium-boron-silicon-nickel matrix that bonds the carbide particles together and fuses the entire hard facing deposit to the part.

32-C is recommmended for applications requiring maximum hardness. Deposits from the powder have a Moh hardness of about 9.3 and contain about 80% tungsten carbide.

31-C produces a lower concentration of carbide particles in the deposit and is less expensive than 32-C. It is recommended for appli-

cations where the maximum durability provided by high carbide concentration is not needed.

The two powders are potentially useful for hard facing pump seals, tools, templates, patterns, pump wear rings, plug gages, mixing blades, polishing masks, plowshares, buffing fixtures and other parts exposed to severe wear conditions.

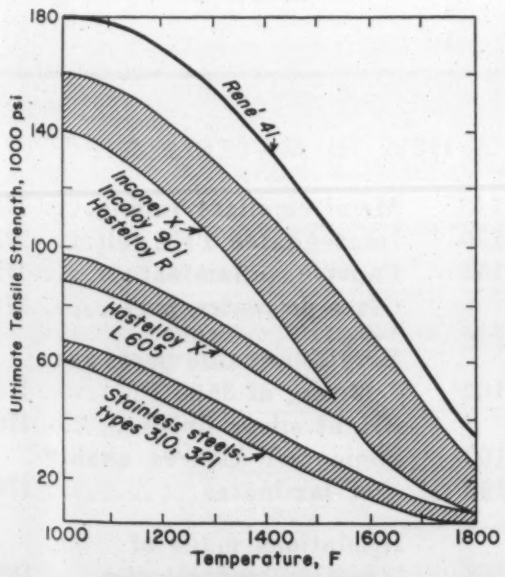
Both 32-C and 31-C can be deposited to any thickness with thermal powder spraying equipment (e.g., Metco ThermoSpray Gun). Deposits are torch fused after spraying to produce a homogeneous, nonporous coating. According to the producer, straight tungsten carbide powders can also be thermal powder sprayed, but the resultant coating is of no value since the carbide particles are poorly bonded together; as a result the carbide mass cannot be fused within itself or to the base metal.

Produced by vacuum melting technique . . .

Nickel-Base Sheet Alloy Is Strong at 1400 F

■ A vacuum melted nickel-base sheet alloy has been developed for use in jet engine and other parts operating at 1200 to 1800 F. The alloy is claimed to be relatively easy to form, weld and machine compared to other materials designed to operate at these temperatures.

Developed by General Electric Co. and trademarked René 41, the new metal is available in sheet, bar, wire and foil from GE's Metallurgical Products Dept., 11-177 E. Eight Mile Rd., Detroit 32. The alloy is also available in sheet, bar and wire from Cannon-Muskegon Corp., 2875 Lincoln St., Muskegon, Mich., Wallingford Steel Co., Wallingford, Conn. supplies the material as cold rolled strip and as welded tube and pipe.



Short-time tensile strength *of René 41 vs other alloys at elevated temperatures.* *(Cannon-Muskegon Corp.)*

Potential uses

René 41 sheet is reported to be well suited for such jet engine parts as turbine casings, afterburner parts, nozzle diaphragm partitions and combustion liners. The mechanical properties of the metal are expected to make it an excellent high temperature bolting and fastener material for high-Mach airframe parts. GE says the alloy is also suitable for other applications requiring high temperature resistance and performance reliability.

Properties

Strength—René 41 is said to offer a 40 to 60% improvement in sheet tensile strengths over existing commercial sheet alloys at 1000-1400 F. Strength tests of the alloy with optimum heat treatment show that the 0.2% offset yield strength at 1200 F is 125,000 psi. The 100-hr stress-rupture strength at 1600 F is 25,000 psi.

Oxidation resistance—The alloy has good resistance to oxidation at temperatures up to and including 1800 F. After 100-hr exposure in slow moving air, intergranular penetration was less than 1 mil per side on the sample tested.

Formability—The alloy has very good ductility and is readily formable in all types of operations. The primary problem is the necessity of rapid heating and cooling rates during the annealing cycle. Distortion is comparatively small on water quenched parts.

Weldability—Welding is said to

ELEVATED TEMPERATURE PROPERTIES[a]

Temp, F ↓	Ten Str, 1000 psi	Yld Str, 1000 psi[b]	Elong, %
Room Temp	206	154	14
1000	203	147	14
1200	194	145	14
1500	126	118	14
1600	90	80	19
1700	58	50	26

[a]Values obtained on bar stock solution treated 4 hr at 1950 F, air cooled, aged 16 hr at 1400 F, air cooled.
[b]0.2% offset.

PHYSICAL PROPERTIES OF RENÉ 41

Density, lb/cu in.	0.298
Coef of Ther Exp, per °F	
70-1000 F	7.5×10^{-6}
70-1500 F	8.5×10^{-6}
70-1600 F	8.7×10^{-6}
Ther Cond, Btu/hr/sq ft/°F/ft	
1100 F	139
1500 F	168
1600 F	175
Specific Heat, Btu/lb/°F	0.108

COMPOSITION OF RENÉ 41

Carbon	0.09
Chromium	19.00
Columbium	11.00
Molybdenum	10.00
Titanium	3.10
Aluminum	1.50
Nickel	55.31

General Electric Co.

Compressor frame *for jet engine is fabricated from GE's René 41.*

offer no major problems. The alloy can be inert-arc welded with or without fillers to form strong, ductile spot welds. Welds are said to closely approach the base metal in strength.

Machinability—René 41 can be machined with straight tungsten carbide cutting tools. The alloy is "gummy" in the soft solutioned condition (obtained with high solution treating temperatures) and should be machined in the fully heat treated, solutioned and aged condition.

Heat treatment

Mechanical properties of the alloy vary with the solution and aging treatment. High solution temperatures give better room temperature ductility and higher rupture strength at elevated temperatures. Lower solution temperatures give higher tensile strengths to the nickel-base sheet alloy.

Two commonly used heat treatments for René 41 are: 1) solution treat 2 hr at 2150 F, air cool, age 4 hr at 1650 F, air cool; and 2) solution treat 4 hr at 1950 F, air cool, age 16 hr at 1400 F, air cool.

An up-to-date report on the status of . . .

Rare Earths for Industrial Applications

by Dr. Richard C. Himes, *Battelle Memorial Institute*

■ Within the past ten years the rare earths have emerged from relative obscurity and are now being considered with interest for many industrial applications. One reason for this interest is the fact that slight differences among the members of the series make possible subtle adjustments in the attempt to provide tailor-made materials for specific applications. Another reason is the recent development of feasible methods of extracting ores for large scale production.

This article presents a review of the latest available information on availability, costs, uses and prospects for the future.

What the rare earths are

The rare earths are a highly reactive, closely related group of metallic chemical elements (atomic numbers 57 through 71). Their close similarity is accounted for by their structures: all have the xenon atom core and three outer electrons which determine, largely, the chemical properties of the elements. They differ only in the numbers of electrons in intermediate levels, which affect size and chemistry of the atoms only slightly.

Yttrium (atomic number 39), although not actually a member of the series, is generally included in any treatment of the rare earths because it is almost invariably found in rare earth ores and is a very close relative chemically.

The 16 rare earth metals are classified into two subgroups: the cerium (or light) subgroup, consisting of elements 57 through 63, and the yttrium (or heavy) subgroup, consisting of elements 64

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Rules of the Competition: A Brief Summary *(For more complete details, see the October issue pp 115-8.)*

1. Materials producers or suppliers are not eligible.

2. The entry must have been designed, redesigned or put into production during the calendar year of 1958.

3. Provide the following information:

a. A detailed description of the product, including photographs, drawings, before-and-after illustrations, etc.

b. A description of the service and/or fabrication requirements that must be met by the product or material(s).

c. A description of the material(s) previously used (if entry is a redesign).

d. A description of the material(s) selected for the entry.

e. An explanation of *how* and *why* the material(s) selected best met the design and service requirements or (if a redesign) resulted in improved performance and/or lower cost. Back up the selection of the material(s) with evidence—facts, data, charts and tables.

4. Entries or portions thereof will not be returned unless requested. Send copies, not originals, of valuable papers.

5. MATERIALS IN DESIGN ENGINEERING reserves the right to publish articles based on winning and non-winning entries. Payment for non-winning articles published will be at usual rates. Judges reserve right to withhold awards at their discretion.

6. All entries must be postmarked not later than *February 2, 1959.*

For description of last year's award winners see Apr '58 issue, pp 127-58.

TO SEND YOUR ENTRY:

Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

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SOME PROPERTIES OF THE RARE EARTHS AND YTTRIUM

Element ↓	Atomic Number	Specific Gravity	Melting Point, F	Cross Section, barns/atom[a]	Magnetic Susceptibility, magnetrons
Yttrium	39	4.47	2825	1.38 ± 0.14	0
Lanthanum	57	6.16	1688	8.9 ± 0.3	0
Cerium	58	6.77	1480	0.70 ± 0.08	2.56
Praseodymium	59	6.77	1715	11.2 ± 0.6	3.62
Neodymium	60	7.01	1875	46 ± 2	3.68
Promethium	61	—	—	—	2.83
Samarium	62	7.54	1925	5500 ± 200	1.55
Europium	63	5.17	1652	4600 ± 400	3.4
Gadolinium	64	7.87	2460	46,000 ± 2000	7.9
Terbium	65	8.25	2550-2730	44 ± 4	9.7
Dysprosium	66	8.56	2685-2730	1100 ± 150	10.6
Holmium	67	8.80	2685-2775	64 ± 3	10.6
Erbium	68	9.06	2685-2775	166 ± 16	9.6
Thulium	69	9.32	2730-2822	118 ± 6	7.6
Ytterbium	70	6.96	1515	36 ± 4	4.5
Lutetium	71	9.85	3000-3180	108 ± 5	0

[a]Cross section for capture of thermal neutrons.

through 71, plus 39.

Availability and cost

Although the rare earths as a group are more abundant in the earth's crust than such "common" metals as copper, lead, zinc and tin, concentrations in economically workable deposits are much more scarce. Up until about 1948 the world was dependent mainly on alluvial beach deposits in India and Brazil for supplies of monazite (the then major mineral source of rare earths) which were limited in availability to about 5000 tons per year.

However recent discoveries of monazite in Idaho, the Carolinas and South Africa, plus the huge bastnasite deposit in California, have turned a serious raw material shortage into a huge surplus.

The problem of separating the elements has been responsible for much confusion in the technical literature on the rare earths. Until recently, the individual elements were available in very small quantities and in rather low purity. The most abundantly available of the rare earth materials was misch metal—an alloy of the metals in proportions roughly as they occur in their more common source minerals.

Since World War II, however, suitable separated materials, of established purity, have become available in ever-increasing quantity,

PRICES OF SOME COMMERCIAL RARE-EARTH MATERIALS

Material ↓	1948 Price, $	1958 Price, $
Misch Metal[a]	4/lb	3/lb
Cerium Metal (98+%)	50/lb	24/lb[b]
Gadolinium Metal (?%)	[c]	350/lb
Dysprosium Metal (?%)	[c]	350/lb
Neodymium Oxide (99.+%)	0.17/gm	0.11/gm
Yttrium Oxide (99.0%)	2.50/gm	0.35/gm
Praseodymium Oxide (99.9%)	3/gm	0.25/gm
Samarium Oxide (99.9%)	7/gm	0.25/gm
Gadolinium Oxide (99.9%)	40/gm	0.55/gm
Europium Oxide (99.5+%)	400-850/gm	2/gm
Thulium Oxide (?%)	2,800/gm	13.35/gm

[a]Misch metal may be described loosely as an alloy of rare-earth metals, roughly in proportions as they occur in the ore. Various quantities of iron may be included. Rare-earth chloride, the salt of misch metal, is now available at 0.25¢ per lb.

[b]For metallurgical development work, iron-free cerium metal of 95+% purity is available at $15 per lb.

[c]Not offered.

and rapid progress is being made in the collection of fundamental property data.

Current enthusiasm over the rare earths as industrial materials stems from new-found feasibility of large-scale production. The atomic energy program has made necessary the

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STRAITS TIN REPORT

MALAYAN TIN BUREAU

New developments in the production, marketing and uses of tin

★

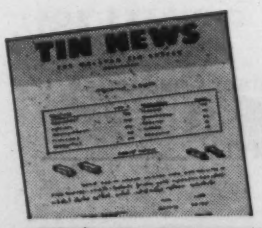
Five times cheaper than stainless steel. That's what the British dairy industry reports about seamless tinned steel milk cans. It finds that a heavy tin coating gives a good adherent finish, provides excellent corrosion resistance, is completely nontoxic, and does not in any way affect the flavor or the nutritive value of the milk.

★

The increasingly important role of tin in this age of the jet and missile is again confirmed. A tin-zinc alloy is being used to plate jet aircraft hydraulic brake parts and thus prevent corrosion. The alloy is 75% tin and 25% zinc.

★

Another new product is available in the popular aerosol cans. It is Freon, an odorless, colorless gas normally used as a refrigerating agent. The aerosol Freon bomb will double as your personal, portable tire pump and fire extinguisher. It can be used to inflate the average tire with 22 pounds of pressure in just 6 seconds. It kills fires by depriving the flames of oxygen and lowering the surrounding temperature.



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The Malayan Tin Bureau

Dept. 24L, 1028 Connecticut Ave., Washington 6, D.C.

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What's new IN MATERIALS

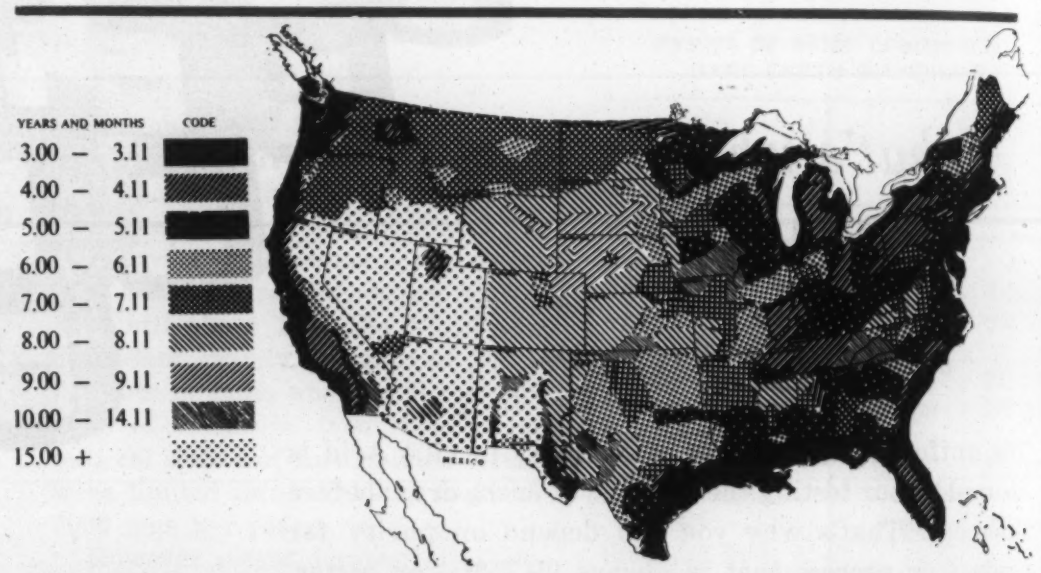
production of large amounts of thorium. However, the average domestic monazite contains less than 6% thorium, with the result that a great volume of the ore must be processed. After the thorium has been removed, rich concentrates remain from which rare earths may be extracted in volume. Such availability, plus the development of reasonably economical separative methods (based primarily on ion-exchange reactions) has made large-scale use of rare earths feasible.

The effect of this increased availability is reflected in the cost data presented in the accompanying table. The figures illustrate the progress of the rare earth industry in the past ten years.

Applications

Electronics—As a result of their electron arrangements the rare earths are presently finding large volume use in lighter flints and arc carbons, and may be useful in other major applications. For example, the rare earths have been found useful as activators in phosphors. Television has, of course, sharply increased our phosphor requirements. However, special phosphor needs will multiply greatly as newer developments, such as wall panel lighting, become household items.

Another application in which the electron arrangements of these elements are useful is that of electron emitters. Rare earth oxides, alone and in combination with thoria, ap-



Corrosion map of U.S.—Pictured here is a map showing the rates at which rust proceeds in different parts of the country. Published in a Rust Index of the U. S. by Rust-Oleum Corp., 2799 Oakton St., Evanston, Ill., the data were obtained by exposing dated and uncoated 28-gage, low carbon, cold rolled sheet steel panels to atmospheres at industrial sites throughout the country. Standard for the Index was the time it took for uncoated steel panels to severely rust.

The Index gives comparative rust rates for 523 U. S. cities with a population over 10,000. Of the cities, 221, or 42%, were indexed as Class I, meaning that uncoated test panels located there rusted severely in less than four years. Class I rust cities include every major industrial area and most of the nation's secondary industrial centers, according to the report. Of the remaining cities, 95 were indexed as Class II, meaning that uncoated panels located there rusted severely in four to five years. The 316 cities included in Class I and Class II comprise 60% of the nation's cities with a population over 10,000.

The Index shows that it takes three years, the fastest rate in the country, for rust to severely corrode a panel in Buffalo and Rochester, N. Y., Erie, Pa., and Miami, Fla. Slowest rust rate (more than 15 years) is in Tucson, Ariz., and Roswell and Sante Fe, N. M.

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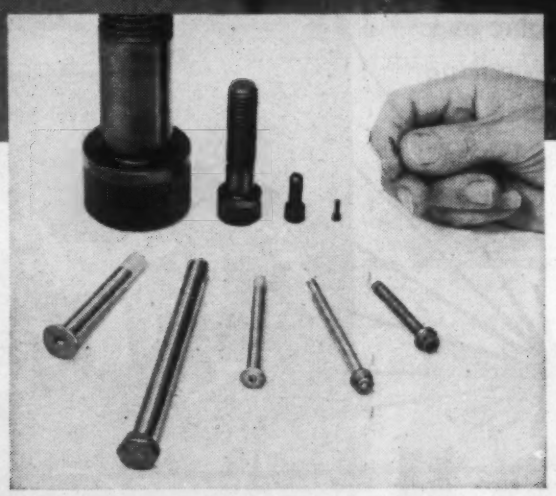

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What's new IN MATERIALS

pear to have a future in vacuum tube cathodes.

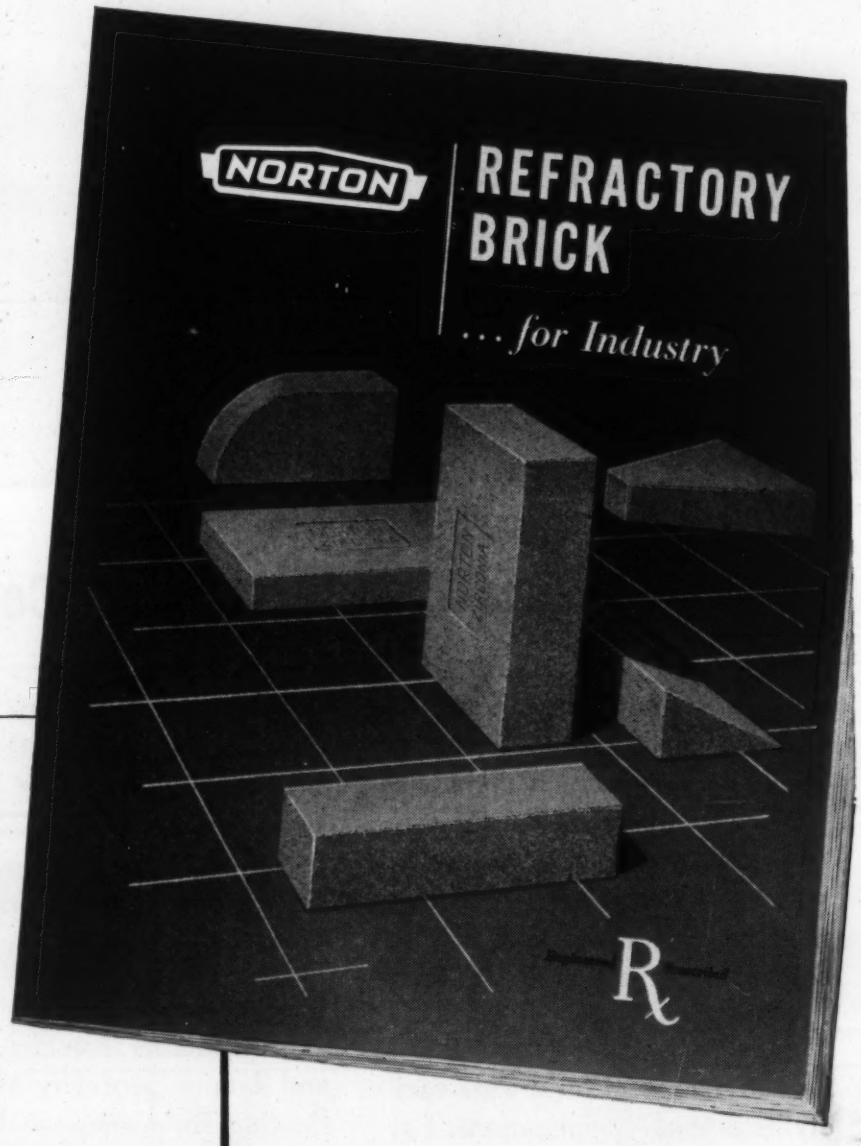
The most exciting recent development in rare earth technology is the recognition of the special ferrimagnetic properties of rare earth-iron garnets of the type 3 $(R.E.)_2O_3 \cdot 5Fe_2O_3$. The low electrical conductivities and low eddy current losses of these garnets make them especially valuable as magnetic core materials in microwave and television applications. The excellent reproducibility of these garnets and their low resonance-line widths (a measure of selectivity of signals) make them superior to spinel ferrites for many applications. The yttrium-iron garnet has shown greatest promise thus far.

Certain of the rare earth elements have been shown to possess magnetic properties which may be useful for several applications. In general, the rare earths are strongly paramagnetic (i.e., attracted by a magnetic field) at ordinary temperatures. In addition, some of the elements are ferromagnetic (may be made to at-

Silicone rubber rolls—Workman is adding Union Carbide's new, general purpose silicone rubber compound XK-1039 to a rubber roll which is subsequently built up to a desired size and cured into a solid mass. Available from Carbide's Silicones Div., 30 E. 42nd St., New York 17, the compound is particularly suited for the fabrication of rubber rolls since it has high hardness (Durometer A 85 ± 5), low moisture absorption, high temperature stability, low compression set and good release properties. Carbide says the compound can be easily molded, calendered and extruded.

Send for this

New Booklet to Help Improve Your High Temperature Processing



Covers Norton refractory brick applications, characteristics, chemical analyses — includes helpful data on materials of construction for temperatures up to 4,400°F.

This new, 24-page Norton booklet can be a dependable guidebook for your selection of the refractories you need to improve production and cut costs in high temperature processing.

Eight Norton-developed refractory materials are covered: ALUNDUM* "T" 87% Alumina; ALUNDUM "A" 99% Alumina; ALUNDUM "L" 99% Insulating Alumina; CRYSTOLON* "G" Silicon Carbide; CRYSTOLON "N" Nitride Bonded Silicon Carbide; MAGNORITE* "K" Fused Magnesia; Zirconia "H" Dense Zirconia; Zirconia "I" Insulating Zirconia.

All essential details are listed, such as: how each material is produced . . . important properties, characteristics and chemical analyses . . . shapes of brick and other molded products that are available . . . representative applications . . . packing methods that assure safe arrival.

Also included are charts and tables of brick shapes and sizes, thermal expansion and conductivity graphs, and a temperature conversion chart.

Norton refractories — engineered and prescribed for the widest range of applications — have helped many users save time and money. The Rx's described in "*Norton Refractory Brick . . . for Industry*" may do the same for you. Write for your copy to NORTON COMPANY, Refractories Division, 350 New Bond Street, Worcester 6, Massachusetts.

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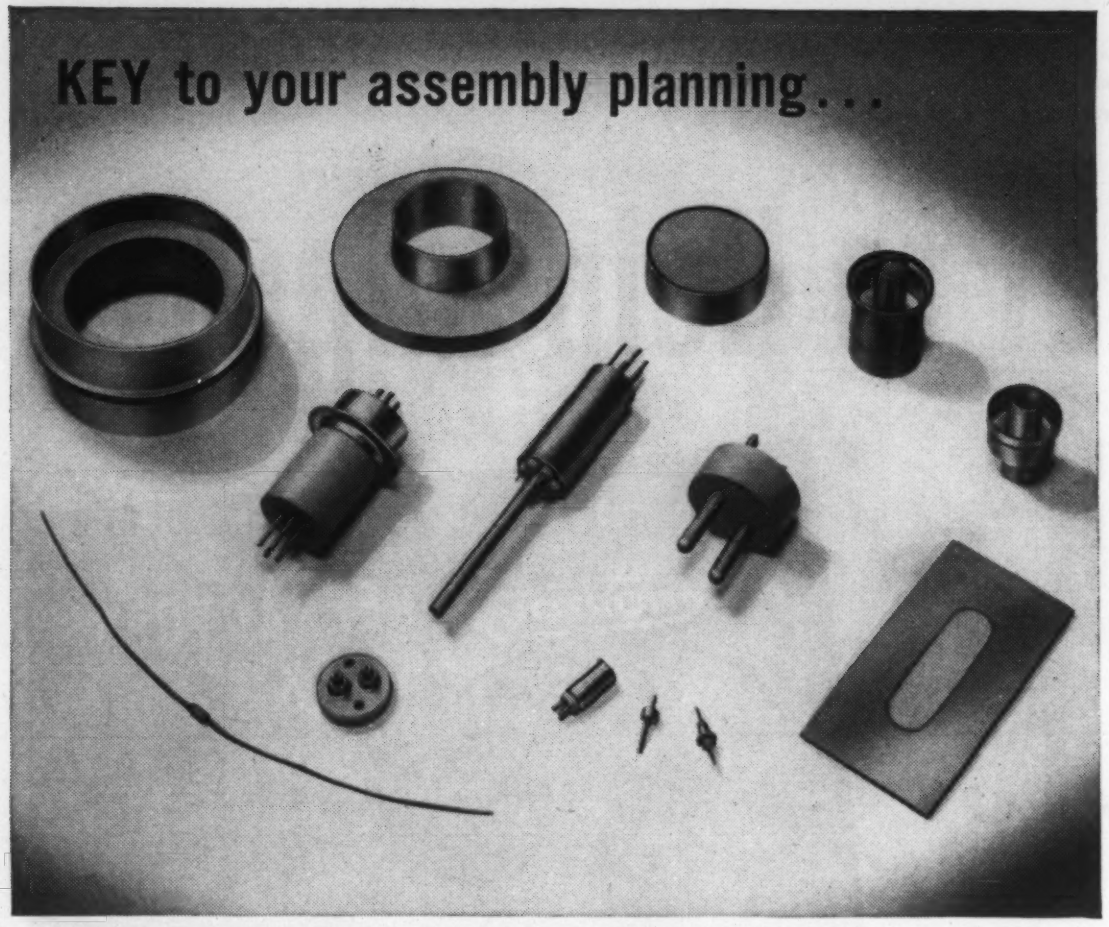

MOLCOTE® Metallized Coating for Ceramics

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MOLCOTE is ideal for a wide variety of assembly applications. For example, it

. . . can be used effectively with copper brazing.

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. . . permits excellent dimensional control.

. . . offers high bond strength.

MOLCOTE surfaces are supplied ready for use for soldering and brazing applications in any temperature range up to 2000° F. MOLCOTE bonds are exceptionally strong with a tensile strength exceeding 10,000 psi.

Frenchtown Engineering Bulletin 1155 contains complete details and data on MOLCOTE Metallized Coating for Ceramics. We'd be pleased to send you a copy for use in your assembly planning. A good time to write for it is *NOW*.

frenchtown PORCELAIN COMPANY

FRENCHTOWN, NEW JERSEY

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What's new IN MATERIALS

tract paramagnetic materials) at low temperature. Transition temperatures between these two states range from 59 F for gadolinium to about —364 F for erbium.

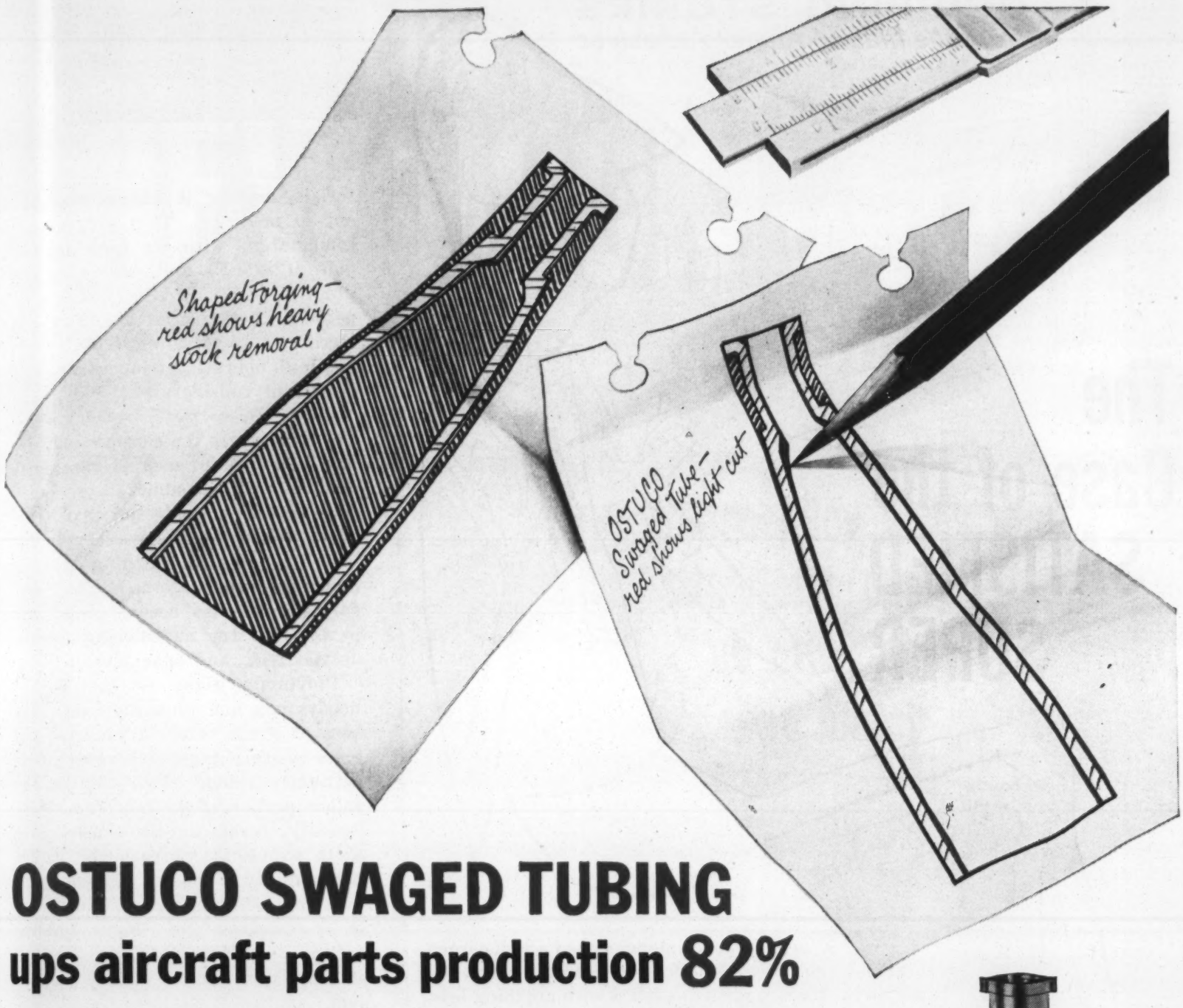
Other rare earth metals, such as lanthanum, gadolinium, erbium and dysposium, exhibit superconductivity at very low temperatures. This property may make them useful in such new devices as cryotrons—memory and control devices that operate at extremely low temperatures.

Nucleonics—Results of recent research indicate that several of the rare earth materials may be of special value in nucleonics. The absorption cross sections (for thermal neutrons) of these elements range from about 46,000 barns for gadolinium to 1.37 barns for yttrium. Materials with cross sections at both ends of this range are especially valuable as reactor materials.

Materials with very high cross sections are needed for control rods (to control the rate of fission in a nuclear reactor by absorption of neutrons) and neutron shields. The characteristics desired in such neutron-absorbent materials include: 1) relatively high cross sections; 2) radioactive decay, after neutron absorption, into daughter atoms of high cross section; 3) high temperature stability; 4) good radiation stability; and 5) ease of fabrication into special geometries.

Among the more "common" elements, boron (750 barns), cadmium (2400 barns) and hafnium (115 barns) all have fairly high cross sections and have been considered for control rod and shielding applications. However, each of these materials is deficient in at least one of the above-mentioned requirements. Gadolinium, samarium (5500 barns), and europium (4600 barns) all have high cross sections and may well provide the best answers to control and shielding problems. To date, the greatest impediment to the development of these materials for use in reactors has been the lack of suitable fabrication techniques. Current research, however, is aimed at overcoming these difficulties.

At the opposite end of the scale, yttrium is of special interest. Its neutron absorption cross section is among the lowest for structural ma-



OSTUCO SWAGED TUBING ups aircraft parts production 82%

Hogged out of a shaped forging, this vital aircraft part in SAE 4140 took 400 minutes to machine.

So the producers, The "Special" Corporation, brought their problem to Ohio Seamless. The solution—an Ostuco Swaged Tube.

Now the chips are down . . . and so is machining time. Down to 220 minutes—*a saving of 180 minutes per part*—with a whopping 82% increase in parts production per workshift.

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AA-8112

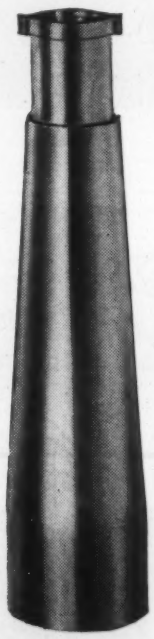

Photo: Courtesy The "Special" Corporation, Brooklyn, N. Y.

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No. 4 of a Series

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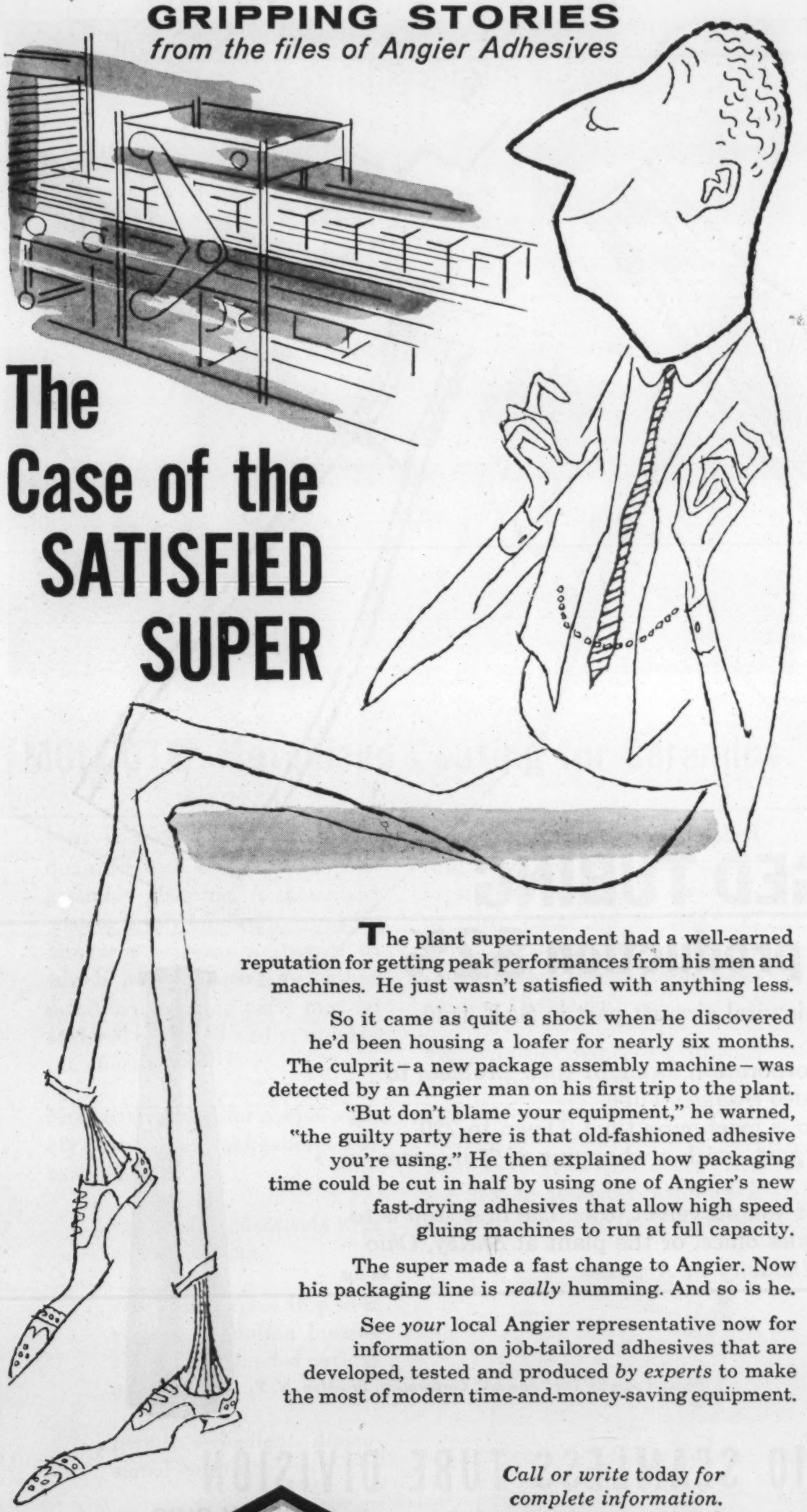

The Case of the SATISFIED SUPER

The plant superintendent had a well-earned reputation for getting peak performances from his men and machines. He just wasn't satisfied with anything less.

So it came as quite a shock when he discovered he'd been housing a loafer for nearly six months. The culprit – a new package assembly machine – was detected by an Angier man on his first trip to the plant. "But don't blame your equipment," he warned, "the guilty party here is that old-fashioned adhesive you're using." He then explained how packaging time could be cut in half by using one of Angier's new fast-drying adhesives that allow high speed gluing machines to run at full capacity.

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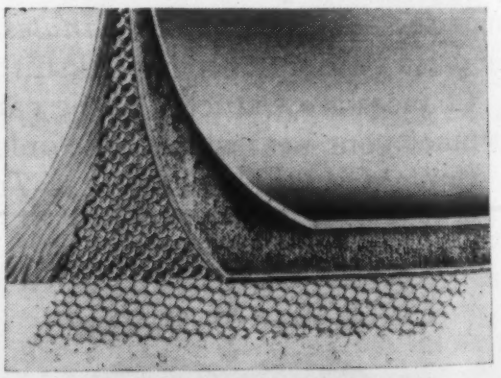
What's new IN MATERIALS

terials, making it almost transparent to neutrons. This property, in combination with its high melting point (2825 F) and its low specific gravity (4.47), makes yttrium especially attractive for use in reactor structures in which stability, weight and high operating temperatures are important considerations.

Ceramics, cermets, refractories— For some years the ceramic industry has been a major user of rare earth materials. It consumes large quantities of cerium oxide and mixed rare earth oxides, which have largely displaced rouge as a polishing agent in numerous applications. The rare earths have also become important in the industry as coloring agents, decalorizers, and opacifiers.

Didymium glass (a mixture of neodymium and praseodynium), has been of great value in welders' and glass-workers' goggles because of its extremely strong absorption in the yellow portion of the spectrum. More recently, ceramists have used rare earth oxides to increase the radiation stability of glasses. Purified lanthanum oxide has been found useful in preparation of high quality optical glass having a high degree of refraction and very little dispersion.

The rare earths offer ceramists another area for development—high temperature refractories. Yttrium



Sandwich panel material—Shown above is a sandwich panel material called Mortonbond that is made up of a core of paper, aluminum honeycomb and rigid foam bonded to steel, stainless steel or aluminum. The construction of the panel is said to provide excellent strength-to-weight ratio and extreme flatness. Mortonbond is available from Morton Mfg. Co., 5125 W. Lake St., Chicago 44.

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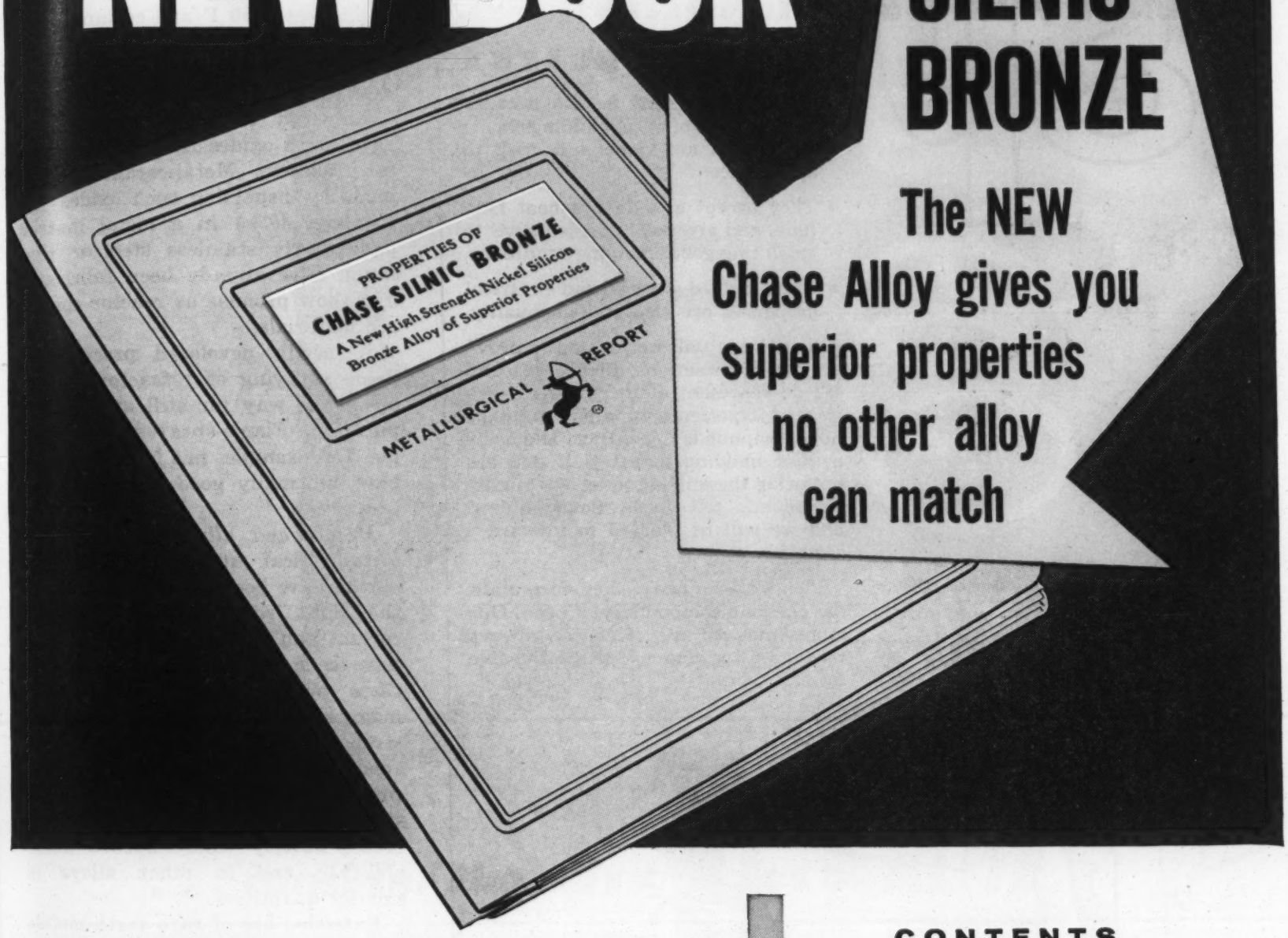
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- Mechanical Properties
- Physical Properties
- Comparison with Other Metals
- Test Data
- Fabrication Information
- End-product Properties

plus other needed information!

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For more information, turn to Reader Service card, circle No. 363

Because they have gained wide acceptance by the molding industry, Plenco 433 and 482, General Purpose Blacks are both produced in large volume. Orders for these compounds repeated from the same molders over and over again, attest to their advantages for general purpose applications—

GENERAL PURPOSE PHENOLICS:

433 • 482 BLACKS

- They are efficient to use because they are fast of cure; moldings made from them are clean and crisp in appearance.
- They accept a wide pre-heat latitude, and are not hypersensitive to small changes in molding conditions.
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Although we will never stop improving our formulations, Plenco 433 and 482 do represent many years of specialized experience in supplying phenolic compounds to a critical and competitive molding industry. If you are not using these modern, tested-quality compounds, tell us the flow required and we will be pleased to forward a sample.

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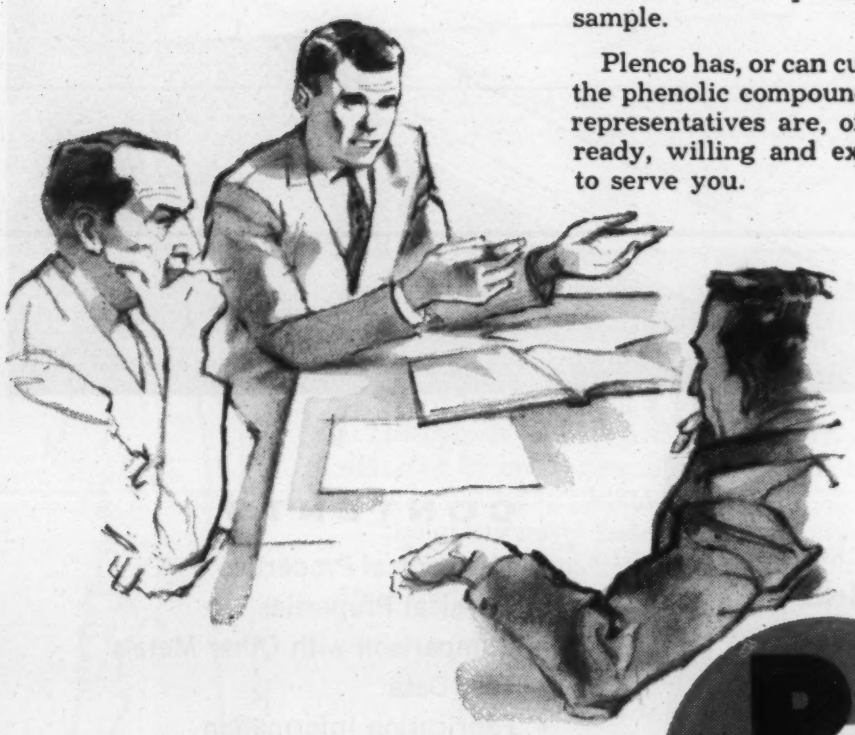

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What's new IN MATERIALS

oxide, for example, has a melting point over 4350 F and cerium monosulfide (melting point, 4530 F) is reported to be readily fabricated into desired shapes and to resist spalling.

Research on cermets containing rare earth oxides has also met with some success. Metal-ceramic bodies, made by dispersing such oxides (up to about 40%) in a metal matrix, particularly stainless steel or titanium, have already been fabricated and show promise as reactor control rod materials.

A newly developed process for flame spraying of refractory oxides opens the way for still another application. Flame-sprayed cerium oxide, for example, has been shown to have unusually good heat radiation properties.

Metals and alloys—In the past, metallurgical applications of rare earths have been confined largely to the light rare earths, primarily cerium and misch metal. Producers have been making moderate use of these materials in aluminum and magnesium alloys (to increase strength); in cast iron, plain carbon steels and low alloy steels (to improve ductility and notch-bar strength); in stainless steels (to increase fluidity and improve workability); and in other alloys in smaller quantities.

Extended use of rare earth metals in these areas appears to be awaiting either sharp reductions in price or demonstration of the roles which individual misch metal components may play in metallurgical processes.

Data already available indicate that hardness of the metals ranges roughly from values comparable to those of lead and tin to that of mild steel. Melting points range from 1480 F for cerium to about 3090 F for lutetium. Hot and cold rolling, forging and extrusion have been successfully carried out with some of the metals in the laboratory.

(continued on p 158)

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Alite withstands high heat, shock and abrasion. Permits you to design for higher temperatures and greater strength. It can be supplied in practically any shape, finished to exacting tolerances. Alite has excellent properties for use as bushings, bearings, valve seats, pump parts, wear plates, wire guides, spools and cores. Any job that demands high mechanical strength and wear resistance, chemical resistance, or reliable performance at elevated temperatures, is a possible application for Alite.

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- Extremely hard, strong, chip-resistant
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117-F

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Some of the needs for high temperature metals may be satisfied by rare earth metals and their alloys. Except for ytterbium, all of the rare earth metals heavier than europium, have melting points over 2370 F and are accordingly ranked as high melting metals. The current trend toward ever-higher temperatures may be expected to thrust these into greater prominence as structural metals or alloying agents.

Other uses—The oxides of several rare earths are being considered as catalysts.

Cerium salts have been found to have waterproofing, mildewproofing and mordanting (dye-fixing) properties, and the paper, textile and leather industries all have need of materials with these properties. Cerium salts used in tanning have been reported to yield high quality leather which is highly water resistant.

Organic chemical compounds of the rare earths, particularly their naphthenates, have valuable paint-drying properties. Rare earths have also been studied as pigments and fillers for paints and plastics.

The future

The tremendous potential of the rare earths is already recognized in many industries. However, there is hard work yet to be done in the study of the properties of all the rare earths and their compounds and in applications research. As more balanced uses of rare earths are achieved, price decreases will follow and industrial uses will develop in many of the areas discussed in this article and in others not yet conceived.

Ceramic Compounds Generate Electricity

Thermoelectric ceramics—ceramics that can convert the heat of a burning fuel or other high temperature source of heat directly into electricity—have been discovered by scientists at Westinghouse Research Laboratories in Pittsburgh. The thermoelectric ceramics, still in the development stage, are described as "mixed valence compounds of the transition metals" (transition metals are a group lying near the center

Tool Steel Topics

BETHLEHEM STEEL

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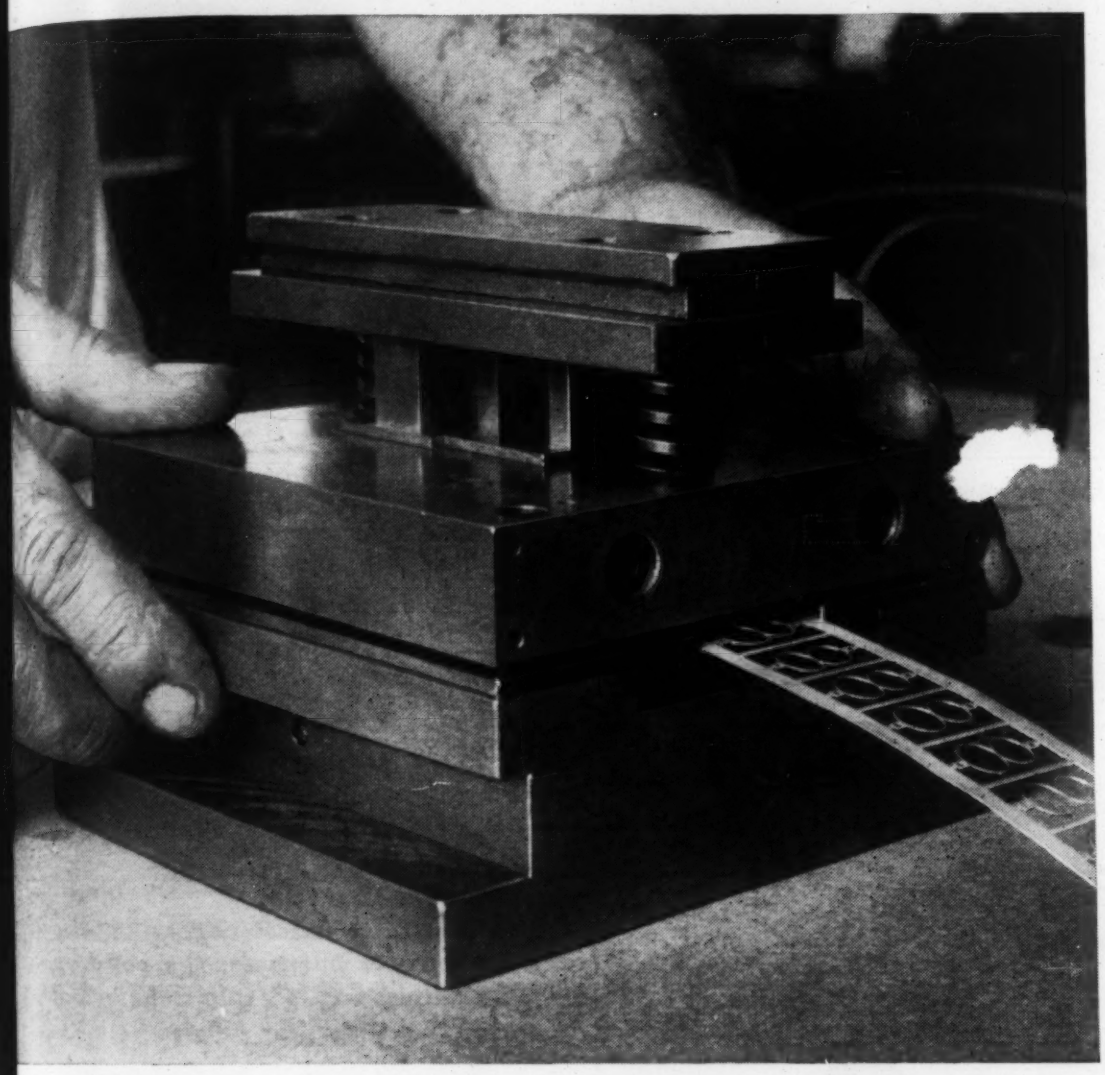


Die of Lehigh H Stamps Delicate Digits

The slim, digit-shaped stampings shown above are anodes, one of a series from 0 to 9, for a numerical indicator tube used in an electronic computer. They are made from several different metals. The width of the anode varies with each digit, and some are as narrow as 0.007 in.

Because of the extremely small clearances involved, the die maker, Be Cu Mfg. Co., Newark, N. J., decided to use progressive dies of a type previously used in producing sub-miniature parts. The dies were made from Bethlehem Lehigh H, supplied by our local tool steel distributor, Lindquist Steels, Inc., Elizabeth, N. J. And because of its low distortional characteristics, Lehigh H proved to be a wise choice.

TYPICAL ANALYSIS

Carbon 1.55	Chromium 11.50
Manganese 0.40	Vanadium 0.90
Molybdenum 0.80	

Lehigh H is our high-carbon, high-chrome grade of air-hardening tool steel. Outstanding because of its minimum size change during heat-treatment, it has the high wear-resistance needed for long-run jobs. Your Bethlehem tool steel distributor has it in stock. Give him a call today.

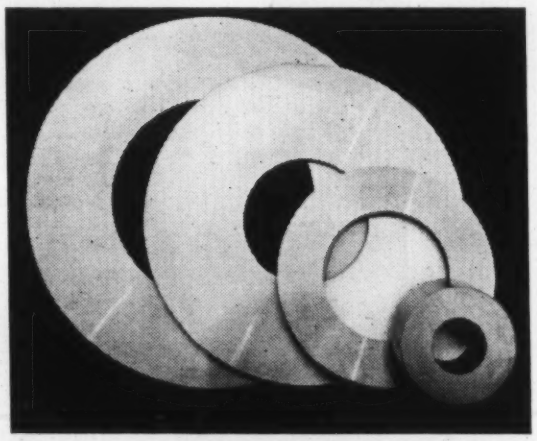
BETHLEHEM TOOL STEEL ENGINEER SAYS:

Heat-Treatment Is SO Important

Investigations of tool failures have shown that improper heat-treatment is responsible for a large proportion of the troubles. Adequate heat-treating equipment is often unavailable, or the equipment is operated improperly.

The importance of proper heat-treatment is often overlooked because it is relatively inexpensive as compared with the cost of the steel and the machining operations. However, just as the links in a chain must be equally strong, the heat-treatment operations on tools must be given proper consideration.

Whenever there is any doubt as to the adequacy of available equipment or its operation, it pays to look for help elsewhere. Commercial heat-treating shops, which are located in every section of the country, have the equipment, the ability, and above all, the experience to handle the heat-treatment of tools.



HOLLOW-BAR MINIMIZES MACHINING COSTS

Yes, you get greater economy in the shop, and a saving in material as well, when you use Bethlehem Hollow-Bar tool steel for any part requiring a center hole in the steel. We make Hollow-Bar by high-speed trepanning, which means coring out hammer-forged or hot-rolled bars, then rough-turning them on the outside. You can put the steel right to work, because the hole is already there. Two grades to choose from: BTR (Bethlehem Tool Room, oil hardening), and Lehigh H (high carbon, high chrome).

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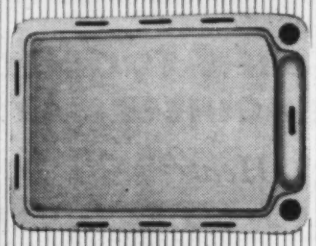
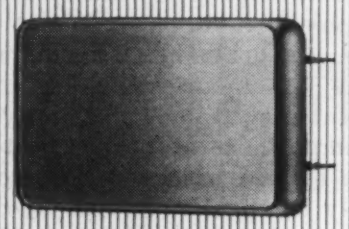
ALUMINUM

PERMANENT MOLD CASTINGS



ITEM No. 1



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Special furnace *like the one shown above is used to prepare . . .*

. . . thermoelectric ceramics. *For experimental purposes, the powdery material is pressed into pellets like those shown in the hand.*

of the natural table of elements and include iron, nickel and manganese).

The ceramic compounds are said to have better thermoelectric properties at high temperatures than thermoelectric intermetallic compounds. The ceramics are reported to have thermoelectric efficiencies at temperatures of 2000 to 3000 F comparable to those of the most promising intermetallic, lead telluride, at temperatures under 1000 F. (For more information on thermoelectric intermetallic compounds, see M/DE, Mar '58, p 118).

Advantages of ceramics

In contrast to solid-state materials heretofore proposed for thermoelectric power generation, the new ceramic compounds are described as inexpensive, readily available, simple to prepare, and not composed of critical elements in short national supply. Other advantages of the

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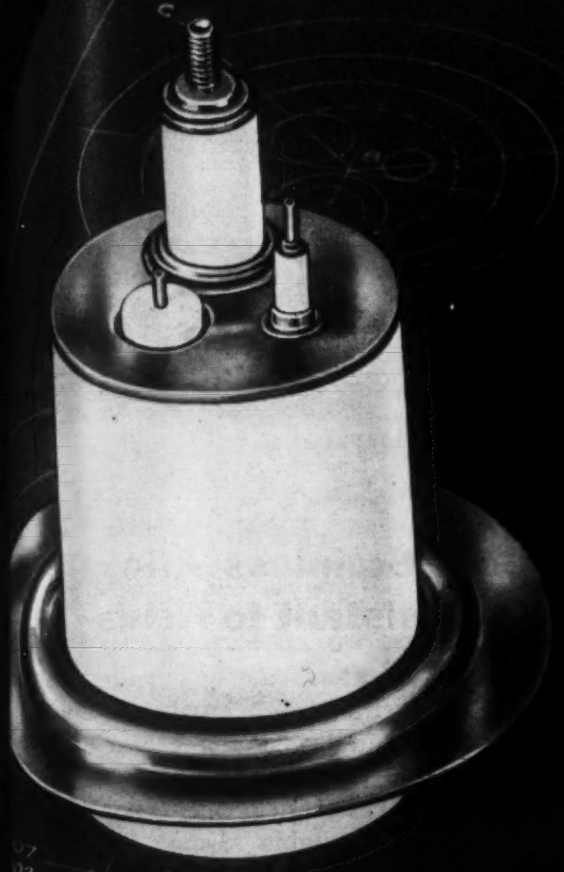
For more information, circle No. 457

Coors

high strength ceramic-to-metal assemblies



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The finest in manufacturing facilities and technical know-how are available to you at Coors—whether your requirement calls for a simple terminal bushing or a complex assembly of ceramic and metal parts. Coors high strength ceramic parts, metalized using high temperature techniques, are brazed to metal parts to provide the combination of physical, electrical and heat resisting characteristics needed for so many applications today.

Ceramic-to-metal bond strengths range normally from 9,000 to 12,000 p.s.i.—or higher depending on design. Brazes can be made at temperatures as high as 1083°C (1981°F.) using copper.

Extremely close dimensional tolerances can be maintained where Coors manufactures the ceramic components, does the metalizing and makes the final assembly of the ceramic and metal parts. Also, this places responsibility in one place.

However, for those who do their own assembly work, Coors will supply the ceramic parts only—either plain or metalized.

Coors engineers will help you work out the mechanical design details of your metalized ceramic parts or ceramic-to-metal assemblies. Contact us at the earliest possible stage of design in order to save time.

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GOLDEN, COLORADO

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Please have your sales engineer see me to discuss ceramic-to-metal assemblies.

Name.....Title.....

Company.....

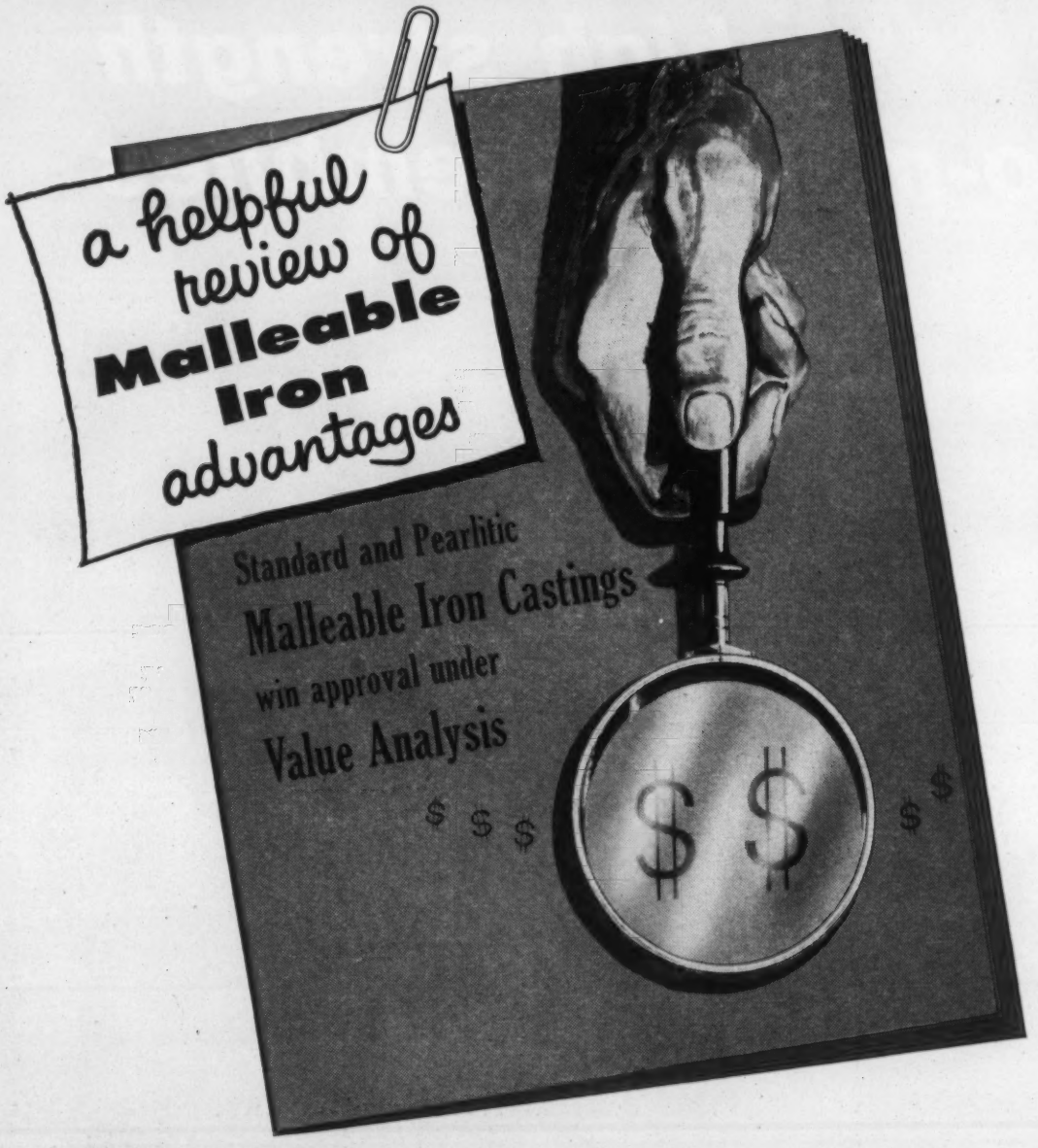
Address.....

City.....State.....

Please refer to our 12-page catalog in Sweet's Product Design File

MDE 118

For your metals data file . . .



Send for this informative brochure!

Whether your approach to selection and purchasing is "Value Analysis", "Purchasing Research", "Cost Reduction Buying" —or just plain "wise buying", the need for background information on materials is apparent to both designers and purchasing people.

How about Malleable?

This new publication— "Standard and Pearlitic Malleable Iron Castings win approval under Value Analysis"—is now available to you. It shows you how the use of Malleable will pay big dividends. Just write for the "Value Analysis brochure".

Consult a malleable foundry engineer at the drawing board stage

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building — Cleveland 14, Ohio

For more information, turn to Reader Service Card, circle No. 396

What's new IN MATERIALS

ceramic compounds:

1. They are inherently stable and chemically inactive, even at very high temperatures.
2. They can be heated indefinitely in air with on open flame without deterioration.
3. They do not require chemical preparation to an extreme degree of ultra-purity as other materials do.
4. Their use raises no technological problems of high vacuum operation, complex electrical or electronic apparatus.

Cast Stainless Alloy Is Resistant to Acids

Stainless steel castings made of a relatively new high strength alloy that is said to combine excellent mechanical properties with excellent corrosion resistance are now commercially available from Lebanon Steel Foundry, 1st Ave. & E. Lehmen St., Lebanon, Pa.

The alloy, called CD4MCu and previously discussed in this magazine (see M/DE, Apr '57, p 172), is said to have better mechanical properties and better corrosion resistance than 18-8 stainless steel. Tests show the alloy has good corrosion resistance in boiling nitric acid. In other tests, the alloy shows no corrosion at room temperature in 10% sulfuric acid, 50% sulfuric acid and 0.5% hydrochloric acid.

The alloy has also been tested in uranial sulfate, and exhibited no stress corrosion cracking.

Electrical Insulations Suitable for Wet Areas

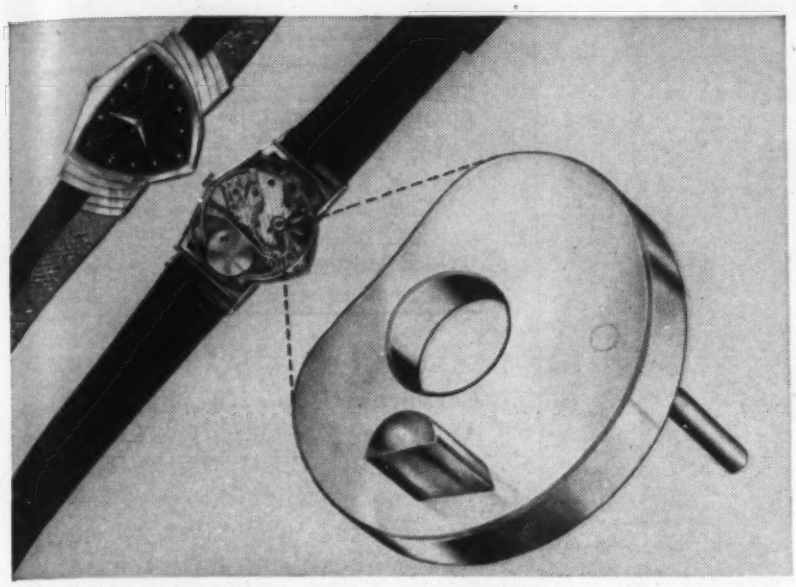
Improved electrical insulations for wet areas can be obtained by using newly developed glass-base melamine laminates. Key to improvement in the laminates are new melamine resins now undergoing evaluation at

---

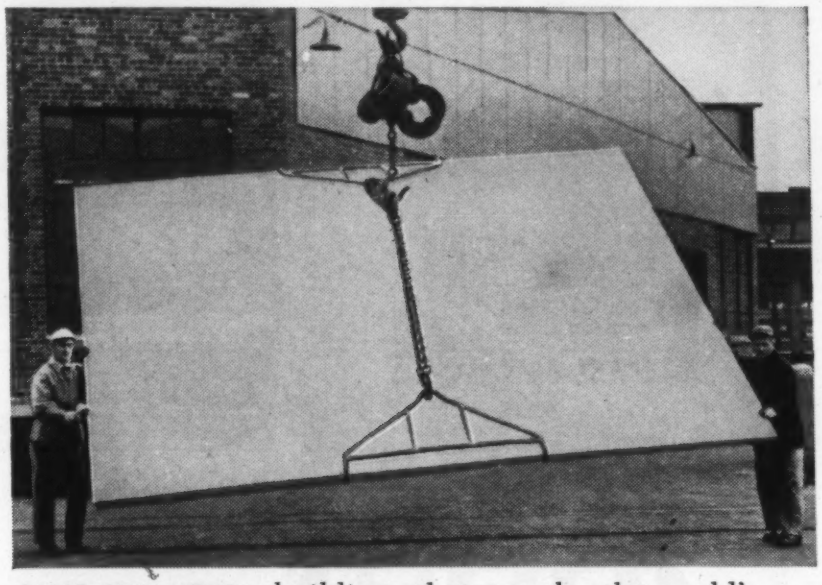
This article is based on a paper by J. C. Pitzer, Formica Corp., and presented at the National Conference on the Application of Electrical Insulation in September. See also "What's New in Electrical Insulation" in this issue, p 108.

1/7000 OF AN OUNCE or

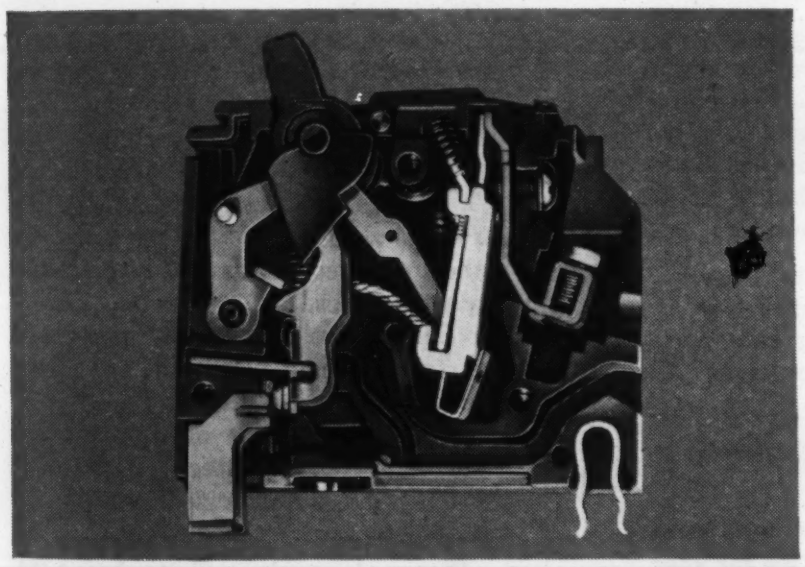
7 tons. In metals, it's the right combination of properties that counts. So just specify the properties you need. You may find the answers from Anaconda very interesting.



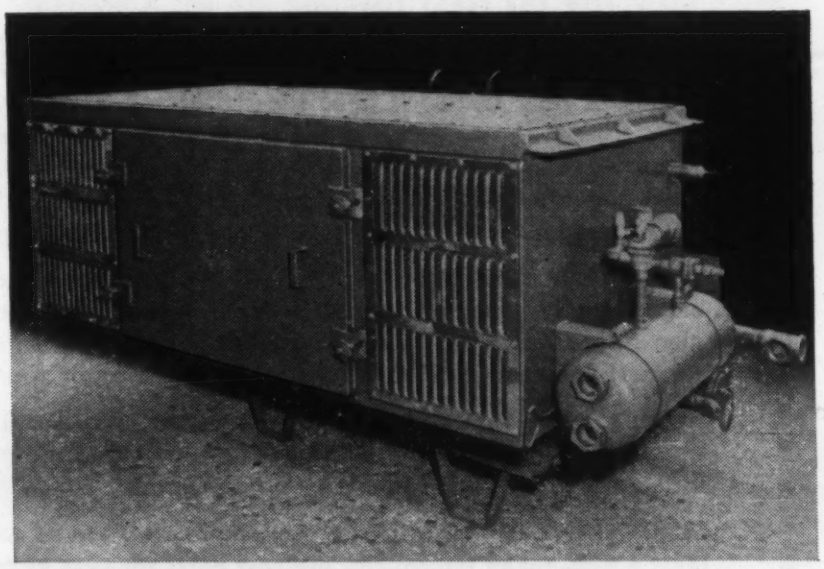
HAMILTON WATCH CO., for the world's first electric wristwatch, demanded these qualities in metal for a vital 1/7000-ounce indexing roller – high hardness and tensile strength; ease of blanking, machining; nonmagnetic properties. Anaconda Ambraloy-901 met the need perfectly. The magnified pinhead-size assembly shown above has a half-round sapphire jewel. The pin limits balance motion.



ALLIS-CHALMERS – building what may be the world's largest surface condenser for Commonwealth Edison Co. – needed tube sheets which combined strength and corrosion resistance with machinability. The answer was Anaconda leaded Muntz metal – 4 plates, each 13′ x 17′, 1½″ thick, weighing over 7 tons. When drilled, plates support 21,960 tubes, for 200,000 square feet of condensing area.



SQUARE D COMPANY needed low electrical resistance, high spring properties, fatigue resistance in critical parts (in color above) of their QO circuit breaker. Electrical resistance of ordinary phosphor bronzes was too high. So was the cost. Engineers of The American Brass Company suggested Anaconda Ambronze-474 and Square D found it had the right combination of properties for the need. And this metal provided superior forming and lower material costs.



THE TRANE COMPANY'S railroad air-conditioning "dry-wet" combination condensers are mounted under cars – facing severe corrosive conditions and a beating from roadbed gravel and stone. Exposed metal, including casing, liquid receiver, 170-gal. water tank, must have superior corrosion resistance, high strength and toughness. Trane has found Everdur®, Anaconda's group of copper silicon alloys, meets its needs. And Everdur is easy to fabricate.

Starting with 93 standard alloys, The American Brass Company can make minor variations in composition, fabrication, and annealing to provide an almost unlimited number of combinations of useful properties. When new or unusual problems rise, ask for the help of the Technical Dept. in selecting the right metal. For such help or a copy of Publication B-32, "Anaconda Copper & Copper Alloys," write: The American Brass Company, Waterbury 20, Conn. 5854

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No electroplating--no mechanical finishing!

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NEW IRIDITE® (Cast-Zinc-Brite)

brightens zinc die castings by chemical polishing, protects against corrosion

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CORROSION RESISTANCE, TOO! New Iridite (Cast-Zinc-Brite) provides exceptional corrosion resistance for bright-type chromate finishes . . . also guards against blueing or darkening by eliminating zinc plate formerly required in bright chromate finishing of zinc die castings.

AS A BASE FOR ELECTROPLATING—Lower mechanical finishing costs are possible where plated finishes are *required* since the brightness provided by this new Iridite may be sufficient.

LET US SHOW YOU what Iridite (Cast-Zinc-Brite) can do for you. Send us at least a half-dozen typical zinc die-cast parts for FREE PROCESSING for your own tests and evaluation. Or, for immediate information, call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified 'phone book. ***IMPORTANT: when you give us samples for test processing, please be sure to identify the alloy used.***

Allied Research Products, Inc.

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For more information, turn to Reader Service card, circle No. 379

What's new IN MATERIALS

ELECTRICAL PROPERTIES OF LAMINATES

Property ↓	P-407	P-579
Density	1.91	1.90
Dielectric Strength (short time), v/mil		
Cond A	427	499
Cond D48/50	376	515
Cond D96/50	325	296
Volume Resistivity, megohm/in.	3.7	7.7

Formica Corp. (a subsidiary of American Cyanamid), 4614 Spring Grove Ave., Cincinnati 32, Ohio.

In developing the resins, prime consideration was given to securing greater heat and water resistance for glass-base melamine laminates to meet Mil Spec MIL-P-15037 (NEMA Grade G-5). An important aspect of Formica's research was the development of new techniques for controlling the molecular weight distribution in the melamine-formaldehyde condensate.

Water absorption and dielectric strength parallel to the lamination after immersion in water at 120 F was the standard on which laminates were appraised. Two experimental laminates were evaluated, P-407 and P-579. Both laminates were made of the improved resins and heat treated glass fabrics.

Formica says P-579 laminate with certain refinements will be offered commercially as FF-60.

Results of work on the two experimental laminates (P-407 and P-579) are summarized here:

Properties

Water absorption—Tests show 1/16-in. thick laminates made of the resins have a water absorption of 0.7% (P-407) and 0.3% (P-579), compared to a water absorption of 2% for conventional glass-base melamine laminates.

Dielectric strength—Both laminates have dielectric strength more than twice that of laminates made of conventional melamine resins after 336-hr immersion in water at 120 F. P-579 gave corresponding values of 0.016 and 7.05 under the same conditions.

Craze resistance—P-407 laminates did not craze when subjected to seven heat cycles in which laminates were

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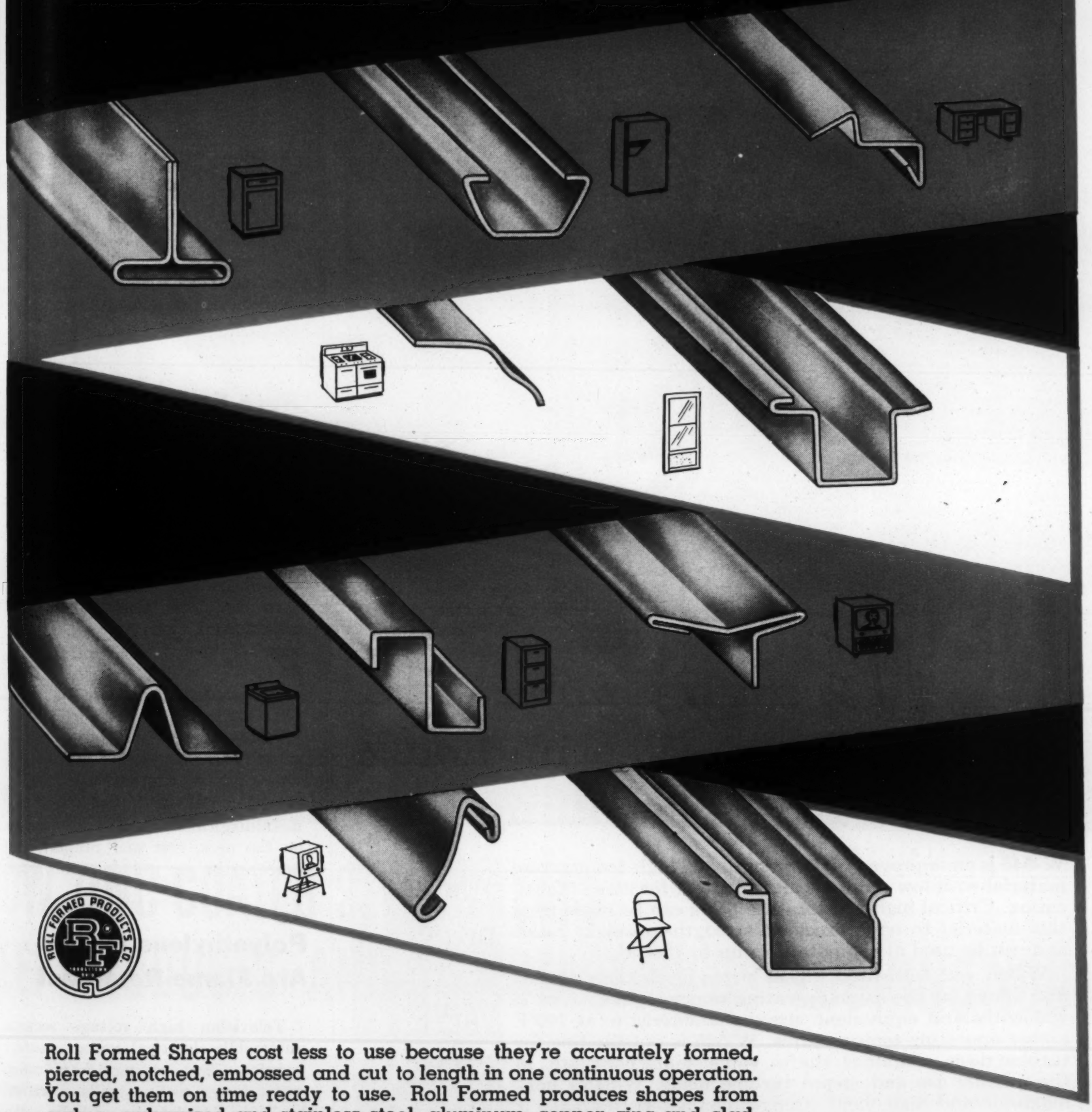
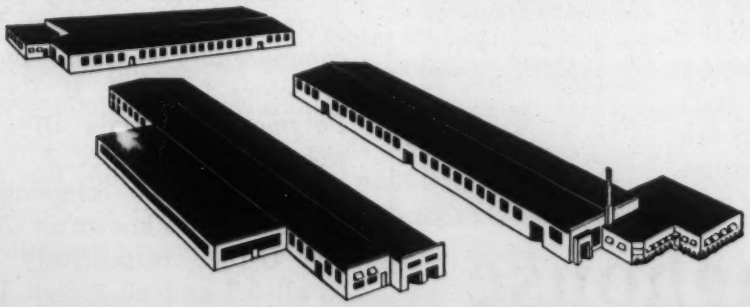


Roll Formed Shapes cost less to use because they're accurately formed, pierced, notched, embossed and cut to length in one continuous operation. You get them on time ready to use. Roll Formed produces shapes from carbon, galvanized and stainless steel, aluminum, copper, zinc and clad-metals. For a fast, thorough analysis of how Roll Formed can help you cut assembly costs, send your prints today. Ask for catalog No. 1555.



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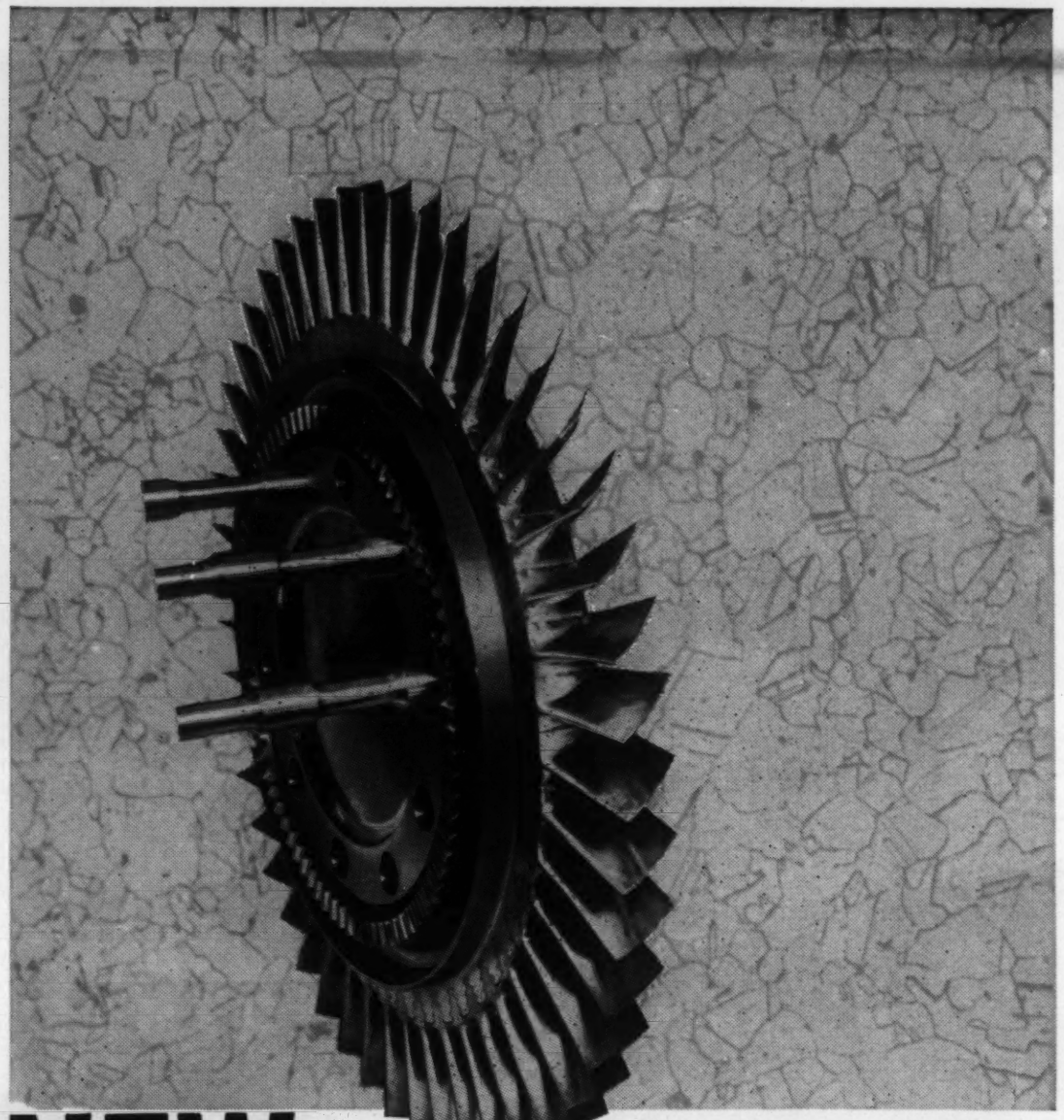

15% — 20% more strength at 1200°F from this turbine disc gives added dependability.

NEW 2 high temperature alloys from Westinghouse W-545 . . .Nicrotung

W-545 is an improved high-strength and high-temperature material with low strategic alloy content for ease of fabrication. Critical high-temperature parts can be made from this material to have excellent strength-to-weight ratios and can be used at temperatures up to 1350°F.

W-545 will withstand higher stress levels than current disc alloys, at the same operating temperatures . . . or it will withstand equivalent stress characteristics at 100°F higher operating temperatures. W-545 is outstanding for turbine discs, couplings, shafts, valve stems, bolts, etc., in the missile, gas and steam turbine fields. W-545's nonmagnetic and high yield strength characteristics make it very desirable for low-temperature uses, such as retaining rings and wedges in electrical apparatus.

NICROTUNG is a new casting alloy for operation at elevated temperatures. Operating at temperatures of 1800°F and higher, Nicrotung is an ideal alloy for turbine blading.

For complete physical and chemical properties on both these NEW alloys, write today to: Westinghouse Electric Corporation, Materials Manufacturing Department, Blairsville, Pennsylvania. J-05007

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heated for 24 hr at 215 F and cooled to room temperature. P-579 laminates did not craze when subjected to seven heat cycles in which laminates were heated for 24 hr at 95 F and 90% RH and 122 F and 10% RH and cooled to room temperature.

Glass-base melamine tubing did not craze when subjected to three heat cycles in which the tubing was heated to 248 F and immersed in water for 24 hr.

Rare Earth Metals Available in Quantity

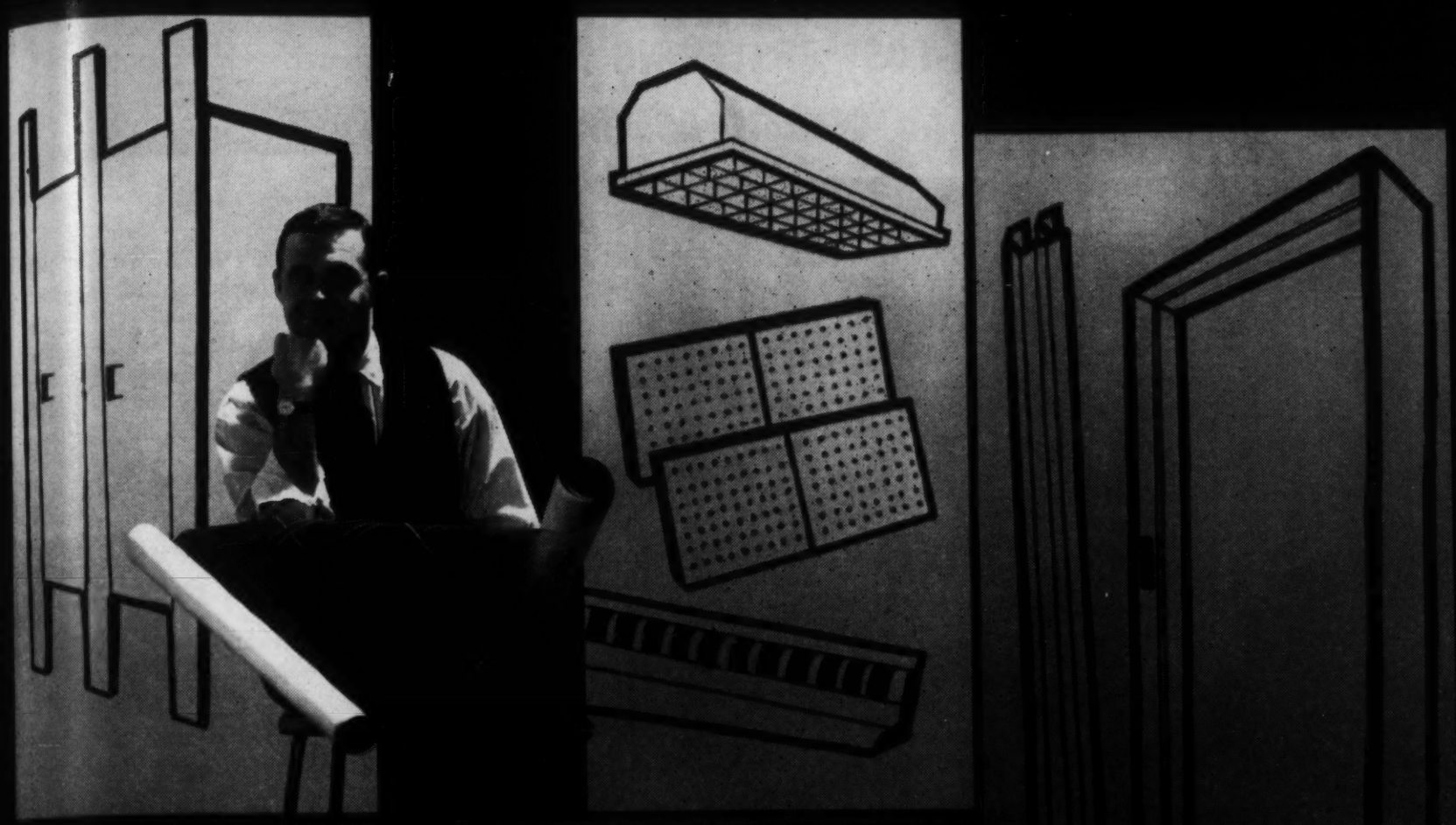
The rare earth metals praesodymium, neodymium, terbium, holmium, thulium, ytterbium and lutetium can now be obtained in commercial quantities from Michigan Chemical Corp., Rare Earths & Thorium Div., St. Louis, Mich. The metals, said to be 99+% pure, are supplied in cast ingots of 1, 1½, 2, 3 and 3½ in. dia. Other rare earth metals such as europium and samarium are available on a custom basis.

These metals, in addition to already available gadolinium, dysprosium, erbium and yttrium, are expected to find use in the nuclear and metallurgical fields. For information on the uses, cost and properties of rare earths see p 144 in this issue.

Polyethylene Resins Are Flame-Retardant

Television high voltage sockets, automobile electrical contacts, safety goggles, fire extinguisher cones, water tower cooling grills, electrical bushings, insulators and baby bottle warmers are some of the uses anticipated for a new series of flame-retardant high density polyethylene compounds. The compounds are now commercially available in a variety of colors from W. R. Grace & Co., Polymer Chemicals Div., 225 Allwood Rd., Clifton, N. J.

The first two compounds of the new series are known as Grex C-1007 and C-1008 respectively (referring to all 0.7 and all 5 melt index com-



HOW ZINC-COATED STEEL SHEETS KEEP PRODUCTS–AND MANUFACTURERS–LOOKING YOUNG

Today, it's almost axiomatic that the more zinc-coated steel you put to work for you, the more freedom your products will have from corrosion—and the more freedom you'll have from customer kicks about corrosion and corrosion-caused maintenance costs.

That's why it pays to use zinc-coated steel sheets in the products you manufacture (such as light troffers, metal ceiling tiles, baseboard heating panels, sliding door hardware, etc.).

Look at the formability, for example. With either electrolytically zinc-coated steel sheets, or continuous process zinc-coated sheets, the tight coating stays tight through the severest fabrication operations. How about corrosion prevention? It's long-lived, uniform, relentless. First cost is low. Maintenance costs are nil. And the results are a lasting credit to your product and your reputation. How about paintability? Electrolytic zinc-coated steel surfaces, chemically treated, are unexcelled for painted products. It lets paint dig in and hold its unbroken smoothness and beauty for keeps.

In electrolytically zinc-coated steel, the name that stands for bonus performance is Weirzin. In continuous process zinc-coated sheets, it's Weirkote. Let us show you how Weirzin or Weirkote will keep your products—and you—looking young.

Write for informative brochure on each today. Weirton Steel Company, Dept. E-24, Weirton, West Virginia.

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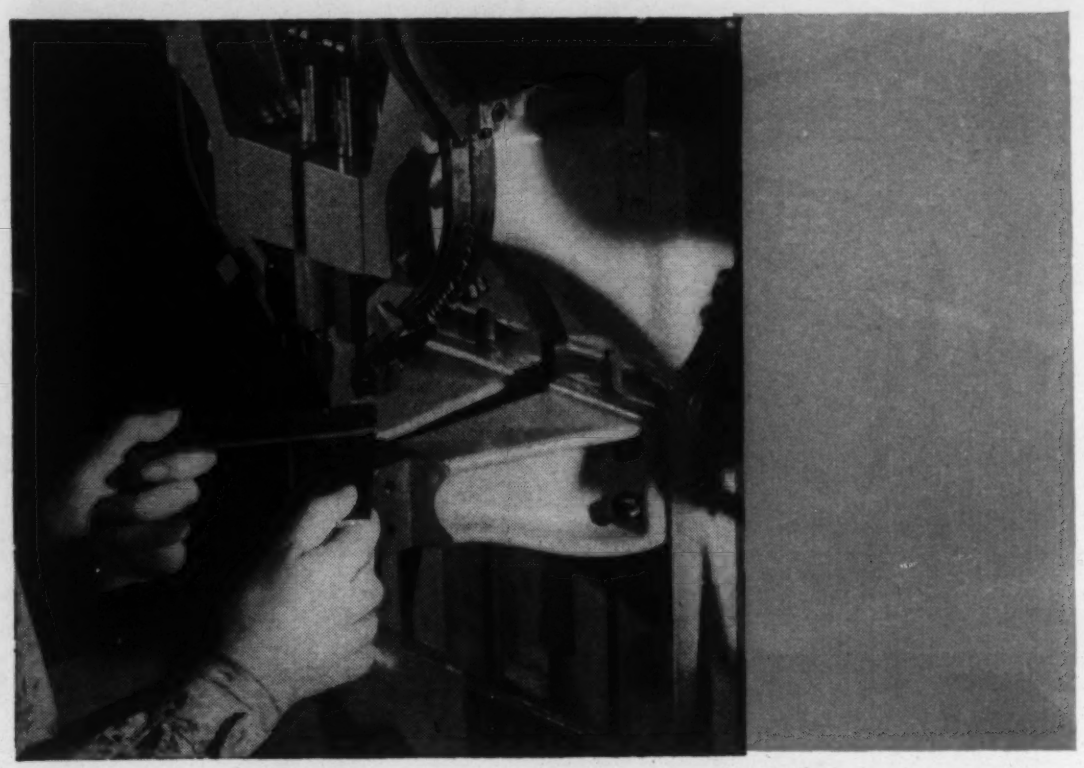
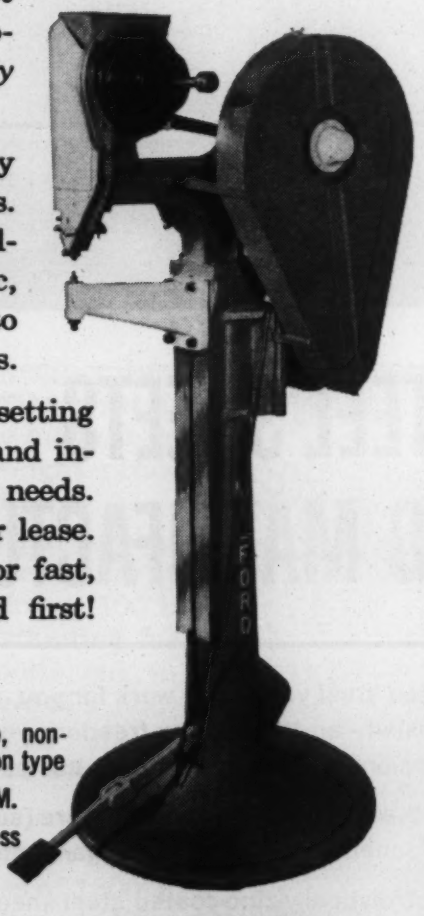


Milford shows you how to cut assembly costs!

Tubular rivets are basically a low-cost fastener. Feed and clinch them with automatic Milford Riveters, and you *multiply* the cost savings inherent in rivets.

The Milford Riveter shown here is only one of a full line of automatic machines. Bench or floor models . . . single or multiple spindle . . . manual or automatic, the Milford Riveter line is designed to solve your toughest assembly problems.

Remember . . . these are *basic* rivet-setting machines. They can be tooled quickly and inexpensively for your particular assembly needs. And it's up to you whether you buy or lease. For a complete line of fasteners . . . for fast, trouble-free assembly—look to Milford first!



MODEL 220-BH

MODEL 220-BH
RIVET CAPACITY: 3/32" dia. by 1/8" length to 9/64" dia. by 3/4" length.
THROAT DEPTH: 11"
POST HEIGHT: From 0" to 18"
HOPPER: Rotary
CLUTCH: Single trip, non-repeating Horton type
FLYWHEEL: 260 R.P.M.
DRIVE: V-belt noiseless

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pounds regardless of color). C-1007 is particularly suited for products requiring high impact strength, and C-1008 is suited for large moldings because it is a free-flowing compound. Both compounds are reported to have good electrical properties.

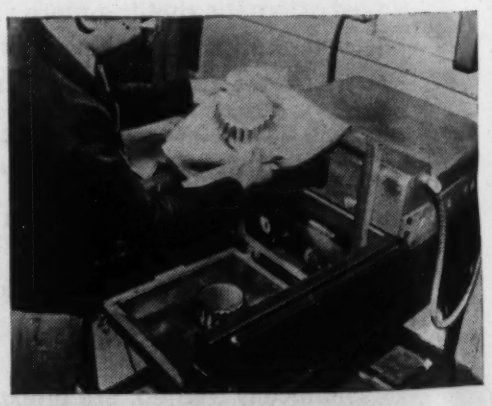
Compound Stops Rust on Finished Parts

A dry, non-abrasive compound of alkaline materials has been developed by Roto-Finish Co., Kalamazoo, Mich. to stop rusting and tarnishing of iron and steel parts after surface finishing.

Called 117-C, the compound is said to neutralize the effects of acid compounds used on metal surfaces during barrel finishing. Its action is said to prevent rusting or tarnishing over extended periods of time as long as a film of the solution is left on the iron and steel parts. The compound is also said to act as an effective deburring aid when used with the proper grinding media.

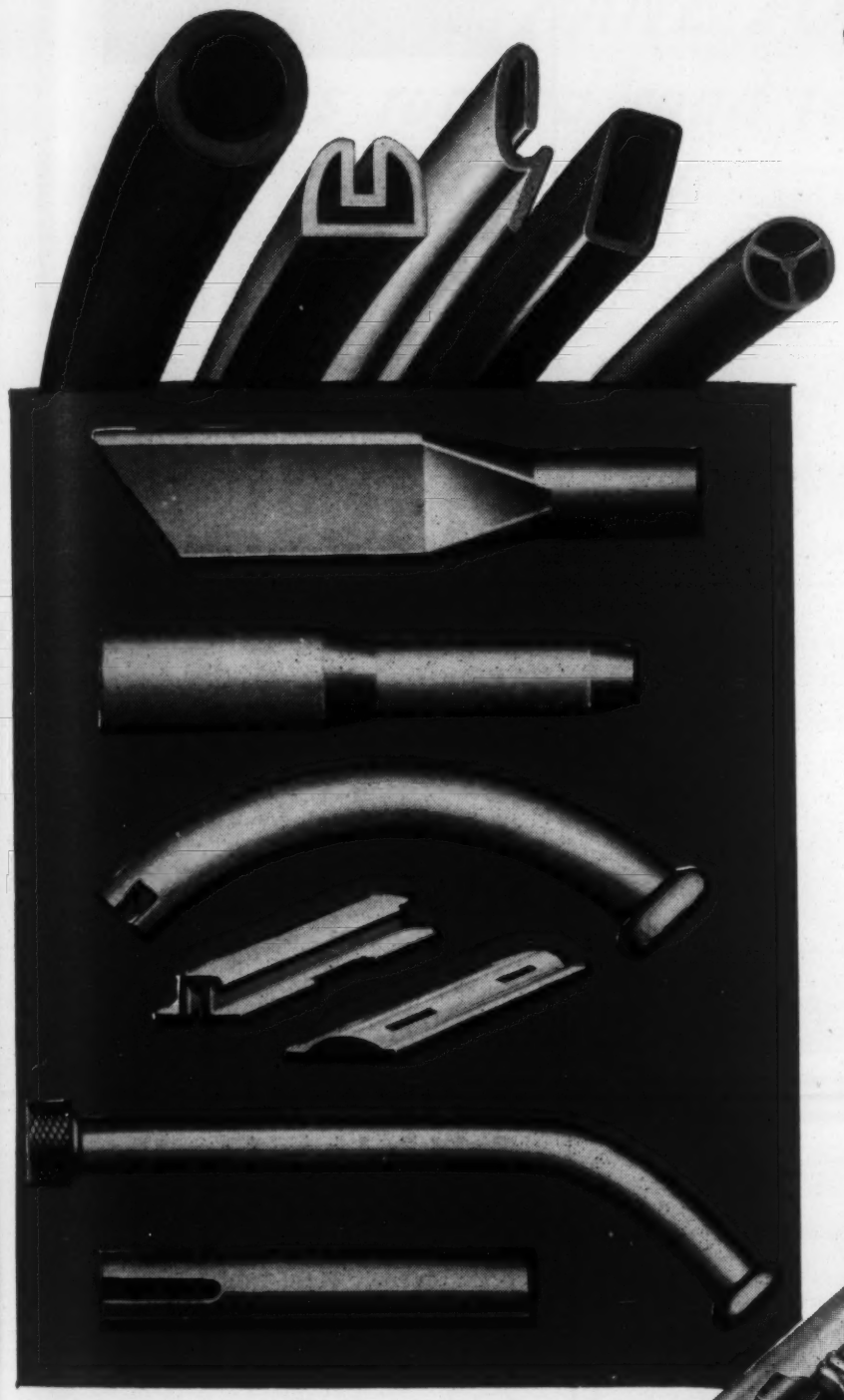
Fabrics Are Shaped by Plug, Vacuum Methods

Recent research indicates heat shaping of Dynel acrylic fabrics, previously discussed in this magazine (see M/DE, July '58, p 125), can be done with the same processes and equipment used for forming thermoplastic films and sheets. Two thermoplastic forming methods currently used to form the fabrics are



Vacuum forming: *the Dynel fabric is heated to 300 F and vacuum-shaped around a mold.*

Consult YARDLEY for:



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We shape, flatten, curve, swedge, drill and perform many other fabricating operations to make your plastic parts ready for use. Close tolerance, absolute uniformity, dimensional stability and high-gloss finish are standard production requirements at Yardley.

3. Packaging ideas

This smart package for the protection of spark plugs from dirt and moisture is made of extruded polyethylene tubing. Heat sealing operation is performed automatically on a machine especially designed by Yardley engineers. We may have the solution to your packaging problem. Write us today.

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Rigid and Elastomeric Vinyl • Acrylic
Cellulose Acetate • Cellulose Butyrate
Kralastic • Styrene • Nylon • Cycolac
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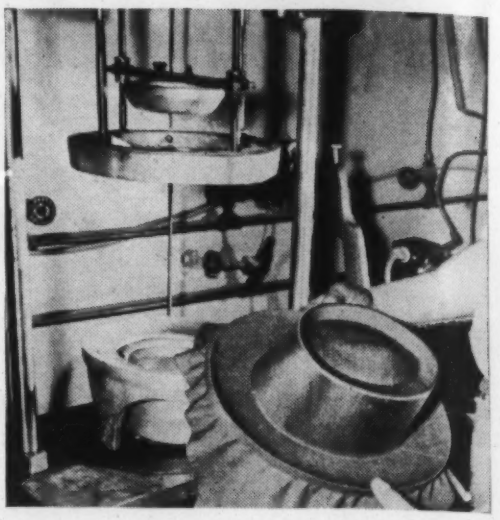
What's new IN MATERIALS



Plug forming: *the Dynel fabric is heated to 290 F, then mechanically shaped by a heated mold.*

shown in the photos on this and the preceding page.

Research was conducted by Textile Fibers Dept., Union Carbide Chemicals Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17.

Metal Capillary Tubing Sold in Long Lengths

Monel, Inconel, types 304, 316, 321, 347 and 446 stainless steel, plain carbon steel and nickel capillary tubing is now being supplied by Superior Tube Co., 1548 Germantown Ave., Norristown, Pa. in lengths up to 3000 ft; the previous maximum length was 500 ft.

Superior says the longer capillary tubing lengths have these three advantages:

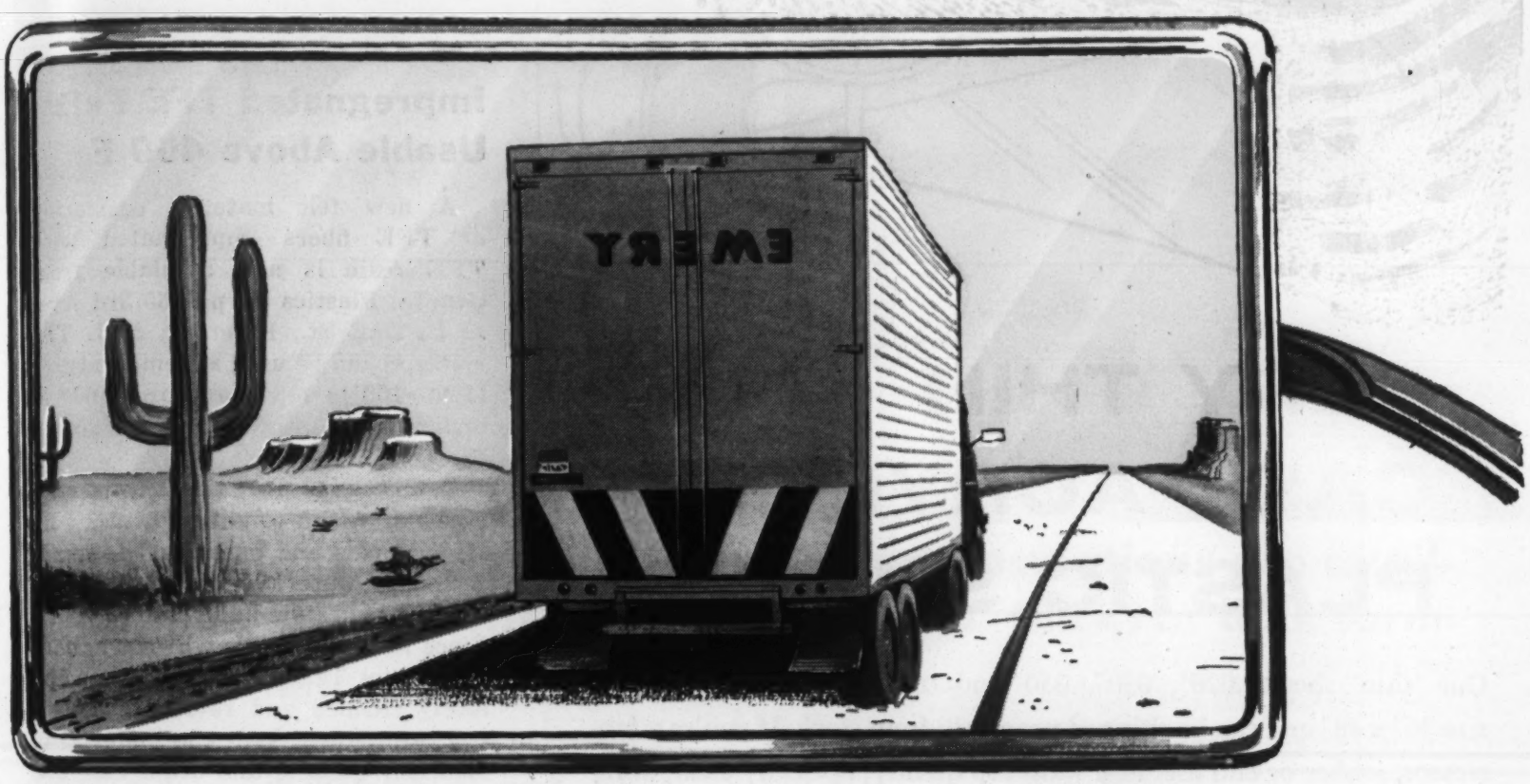
1. Greater uniformity than is possible when drawing the same size of tubing at different times under different conditions and with different dies and mandrels; this greater uniformity facilitates instrument calibration.

2. Possible use of one continuous length of tubing from the sensing element to the indicating, recording and controlling sections of instruments, even though the sensing element is distantly located.

3. Continuous automatic fabrication of tubing with minimum downtime for changing reels.

According to the producer, the commercial tolerance spread on both outside and inside diameters is 0.002

RIGID URETHANE FOAM INSULATION
passes rugged "road test"!

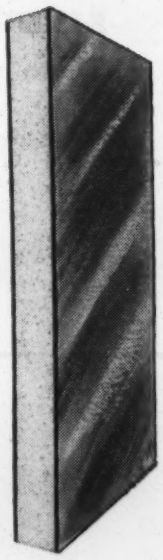


In use under actual road conditions, rigid urethane foam insulation is rated excellent for all-around performance in refrigerated truck trailers!

It is currently proving its superiority as well in "reefer" cars, home appliances, and industrial, commercial and other refrigeration equipment.

Besides combining insulating efficiency with many practical plus values, urethane frequently costs less installed. Molded, sprayed or foamed in place or worked from slab stock, urethane foam saves production time and labor. Since it adds rigidity, lighter structural materials can be substituted in many applications

If you want to explore the use of urethane foam insulation, our application laboratory can give you valuable assistance. We produce NACCONATE® Diisocyanates, essential components in all urethane formulations.



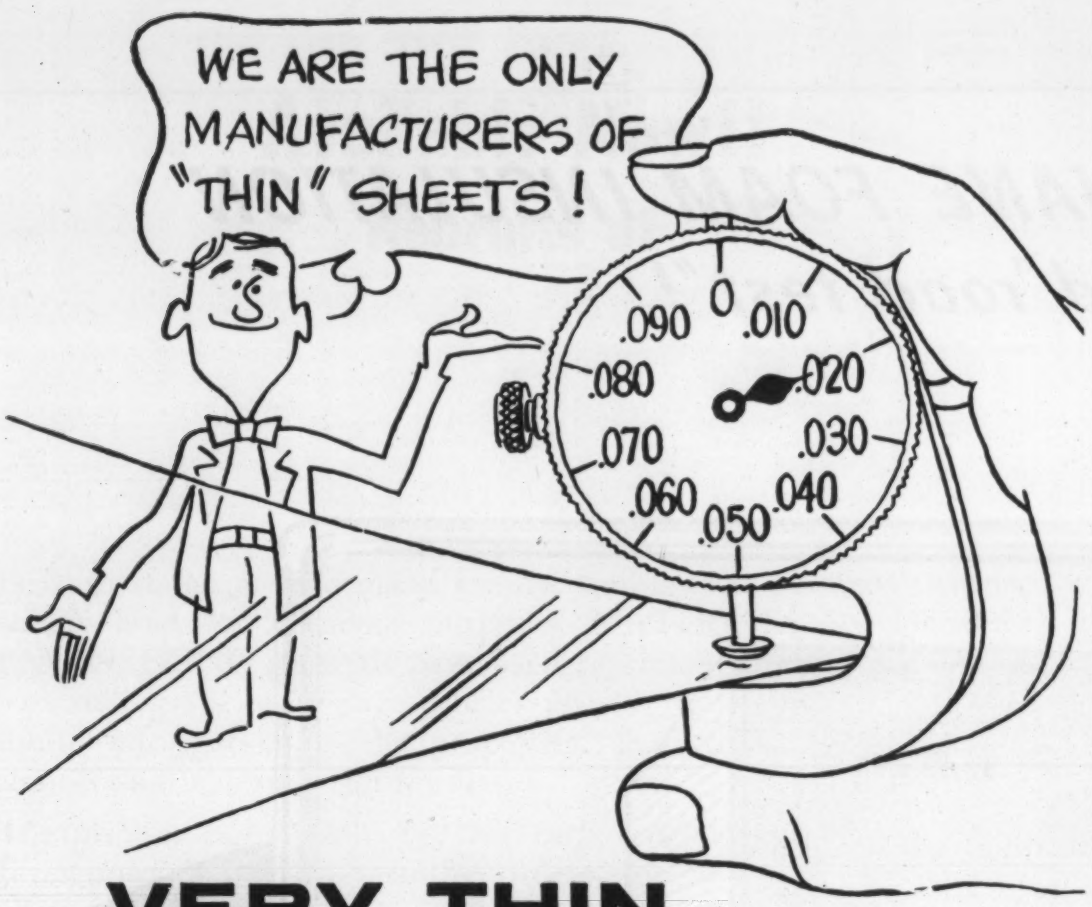
Modular "sandwich" panels of rigid urethane foam, provide complete isolation for truck trailers, eliminating heat loss due to through-metal contacts.

Lightweight urethane retains its high efficiency longer. It has low moisture pick-up, doesn't "pack down" and withstands 250°F. without deterioration. Modular construction facilitates repair and replacement.

NATIONAL ANILINE DIVISION
40 RECTOR STREET, NEW YORK 6, N. Y.
Atlanta Boston Charlotte Chattanooga Chicago Greensboro
Los Angeles Philadelphia Portland, Ore. Providence San Francisco

Allied Chemical

For more information, turn to Reader Service card, circle No. 518



VERY THIN CAST ACRYLIC PLASTIC SHEETS

Our "thin" sheets, .020", .030", .040" and .050", are available in sheet size 36" x 48" and can be shipped promptly from stock. If you're a fabricator, jobber or end user and want top quality, optically clear, abrasion resistant Thin Acrylic Sheets in a hurry, call on Cast Optics Corp.

WRITE or phone for complete specifications and samples of EVR-KLEER Cast Acrylic and other special formulations such as CR-39 Thermosetting Plastic Sheets.

Other flat sheets in sizes up to 48" x 72" with thicknesses from .060" to .500".

All sheets cast to closest thickness tolerances.

First Grade or S-Grade in clear or translucent white.

Dependable 24 hour service.

CAST OPTICS CORPORATION

551 Newman St., Hackensack, N. J.
HUbbard 9-4000

Manufacturers of EVR-KLEER* Rigid Plastic Sheets

EVR-KLEER* Registered Trademark of Cast Optics Corp.

For more information, turn to Reader Service card, circle No. 468

What's new IN MATERIALS

in. on tubing sizes up to 3/32-in. o.d. and 0.003 in. on tubing sizes from 3/32 to 3/16-in. o.d. incl.

The 3000-ft. long tubing is supplied in coil diameters of 18, 24, 30 and 36 in.

Impregnated TFE Felt Usable Above 400 F

A new felt material consisting of TFE fibers impregnated with TFE resin is now available from General Plastics Corp., 165 3rd Ave. at E. 26th St., Paterson, N.J. The material can be used at temperatures from −100 to 400 F and up to 600 F under certain conditions, according to the producer.

Being all Teflon, the felt is capable of withstanding attack by strong acids and bases and is unaffected by water, common fuels, lubricants, hydraulic fluids and solvents. Since most materials will not adhere firmly to Teflon, the felt can be easily cleaned and re-used.

The producer says the material is ideal for gaskets and seals that are to be exposed to corrosive fluids and to high temperatures. In one application the impregnated TFE gaskets are still in use after 18 months' exposure to 99.3% sulfuric acid; material previously used had to be replaced every week.

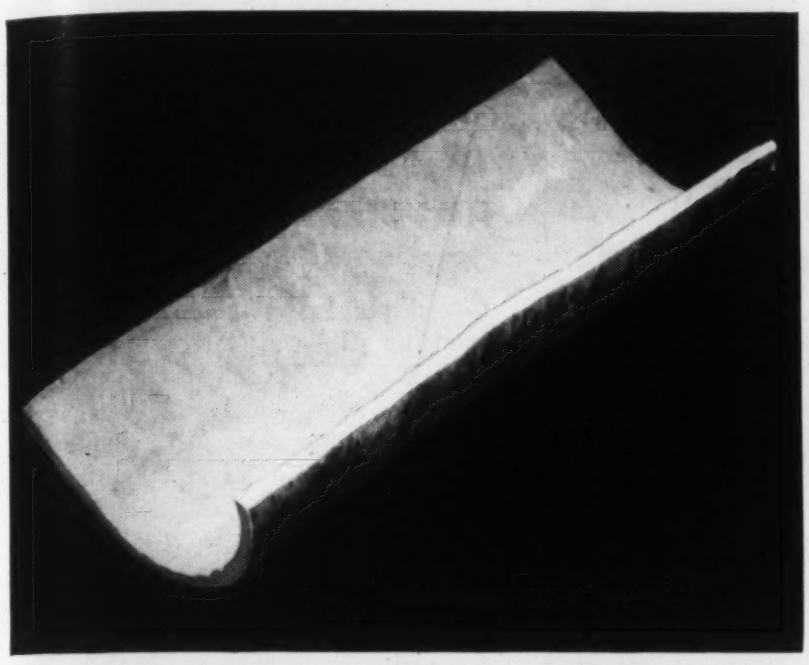
The felt is supplied in sheets approximately 30 × 26 in. and in thicknesses of 1/16 in., ⅛ in. and ¼ in. It is also supplied in half and quarter sheets.

Paper-Base Laminate

A plastics laminate made of an epoxy-impregnated paper has been developed especially for printed circuit and other electrical applications. Called Grade EP-22 by the developer, Synthane Corp., Oaks, Pa., the laminate sells at a much lower price than the company's glass-base epoxy laminates (Grades G-11 and G-10).

The material has a flexural strength of 20,000 psi lengthwise and 16,000 psi crosswise, and a shear strength of 11,000 psi. The laminate is supplied in sheets 36 × 36 in.

Look to L·O·F Glass Fibers for HIGH temperature insulations with LOW weight and space factors



L·O·F Glass Fibers' High Temperature Insulations are available in strong felted sheets (3/16" or ½" thick) or bulk form.

MICRO-QUARTZ®

Insulation for temperatures in the order of 2000° F

Felted Micro-Quartz will withstand temperatures as high as 3000° F for short periods of exposure, and continuous exposure at 2000° F*.

GLASS MICRO-FIBERS

Insulation for temperatures up to 1000° F

Felted glass Micro-Fibers will withstand exposure to temperatures up to 1000° F*.

**except where reaction might occur with certain chemicals or materials.*

Made from extremely fine fibers, Micro-Quartz and Glass Micro-Fibers offer superior thermal conductivity, amazingly light weight and low heat capacity. The difference lies primarily in the temperature range.

They are particularly effective for:

- **equipment subjected to frequent heating cycles at high temperatures.**
- **equipment requiring maximum thermal resistance per unit thickness of insulation, and high diffusivity.**
- **portable equipment where space and weight are critical factors.**

L·O·F GLASS FIBERS

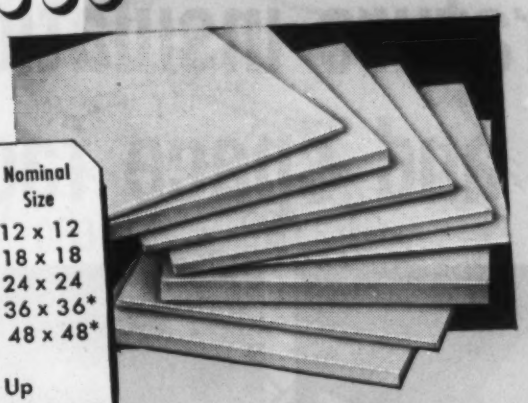
If you have a high-temperature design problem, write on your letterhead to: *L·O·F Glass Fibers Company, Dept. 37-118, 1810 Madison Ave., Toledo 1, Ohio.*

L·O·F GLASS FIBERS COMPANY TOLEDO 1, OHIO

For more information, turn to Reader Service card, circle No. 498

Teflon*...

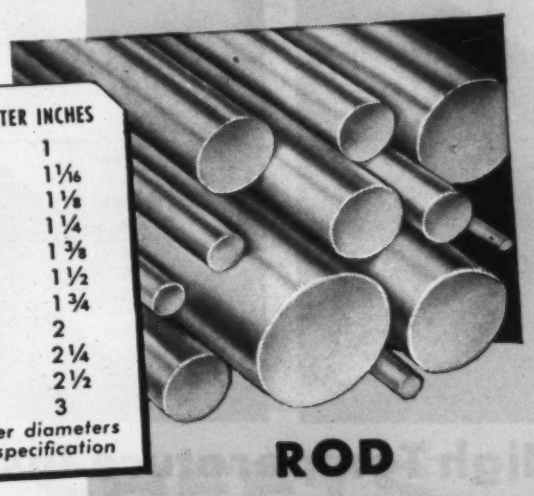
Your Best Source Is JOHN CRANE



Thickness Inches	Nominal Size
1/16	12 x 12
3/32	18 x 18
1/8	24 x 24
3/16	36 x 36*
1/4	48 x 48*
3/8	
1/2 & Up	

* Can be furnished in ½ sheets

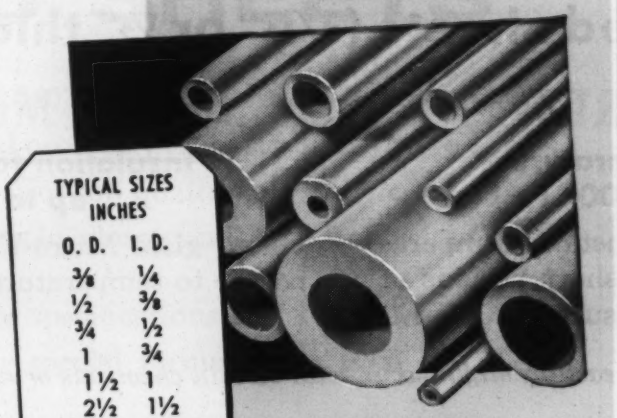
SHEET



DIAMETER INCHES	
1/4	1
5/16	1 1/16
3/8	1 1/8
7/16	1 1/4
1/2	1 3/8
9/16	1 1/2
5/8	1 3/4
3/4	2
7/8	2 1/4
	2 1/2
	3

Other diameters on specification

ROD



TYPICAL SIZES INCHES	
O. D.	I. D.
3/8	1/4
1/2	3/8
3/4	1/2
1	3/4
1 1/2	1
2 1/2	1 1/2
3	1 3/4

TUBING

HERE'S WHY: You can order in quantity and in a wide variety of sizes—and be certain of complete uniformity throughout. Our strict density control assures you thoroughly non-porous Teflon—free from any flaws which might possibly affect your end use or product. Dimensions are accurate to your most critical tolerances—no rejects, waste of material or loss of time. You get product purity—Teflon at its best in every one of its remarkable characteristics. Delivery is prompt—you get the quantity you want when you want it.

Since the availability of Teflon, "John Crane" engineers have worked with Industry to successfully solve innumerable problems and develop new applications. *You can benefit from their experience and know-how.*

Characteristics of Teflon

CHEMICAL
Completely inert.

ELECTRICAL
Very high dielectric strength.
Extremely low power factor.

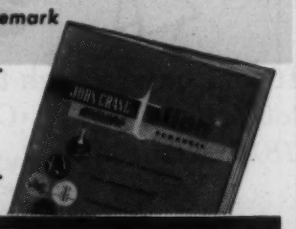
THERMAL
Temperature range
−300° to +500° F.

MECHANICAL
Strong, flexible, weather resistant.

LOW COEFFICIENT OF FRICTION
Absolutely non-stick.

* DuPont Trademark

Request full information and ask for our bulletin, The Best in Teflon.
Crane Packing Co., 6460 Oakton St., Morton Grove, Ill.
(Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.



John Crane

CRANE PACKING COMPANY

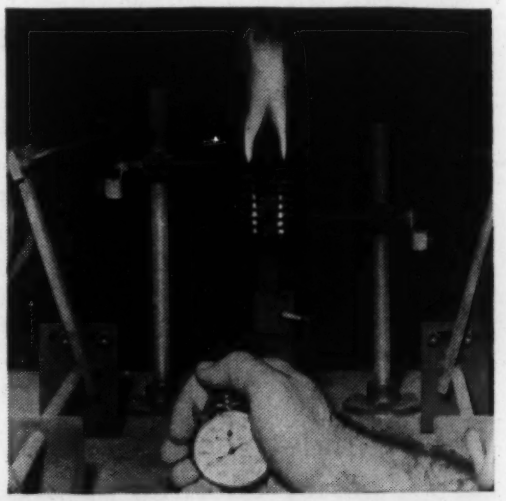
What's new IN MATERIALS

and 36 × 72 in. in thicknesses of 1/32 to ¼ in. Grade EP-22 laminate is also supplied with copper cladding on one or both sides in standard foil thicknesses.

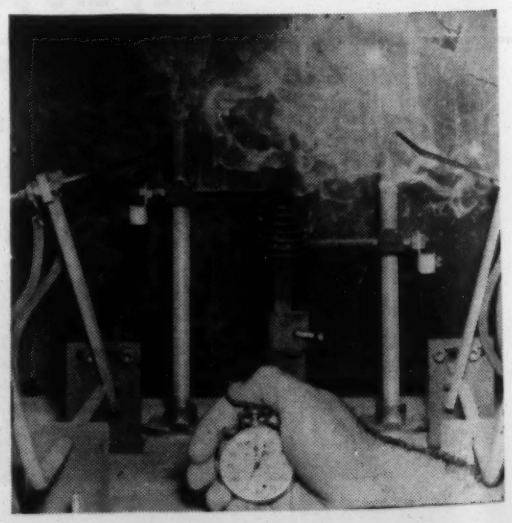
Glass-Polyester Parts Are Flame-Retardant

A flame-retardent fiberglass-reinforced polyester compound is being used by Glastic Corp., 4321 Glenridge Rd., Cleveland 21 for the molding of such electrical insulating parts as bus support insulators, bushings, terminal plates and switch mounting brackets. The compound, called UMG 1500, is recognized by Underwriters' Laboratories for use at 300 F.

The producer says parts molded from the compound are competitive

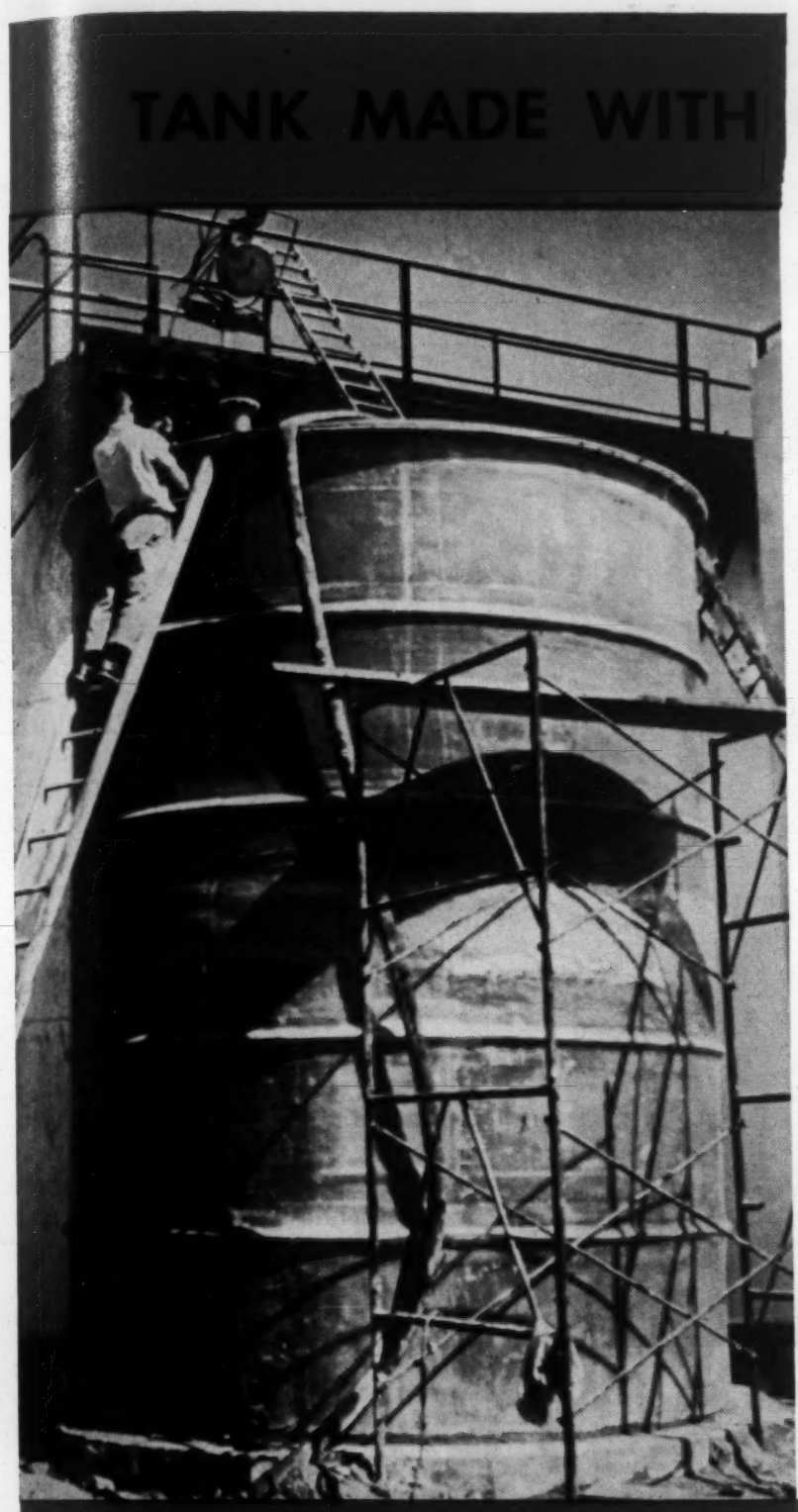


Reinforced polyester *resists ignition for 130 sec before bursting into flame, then...*

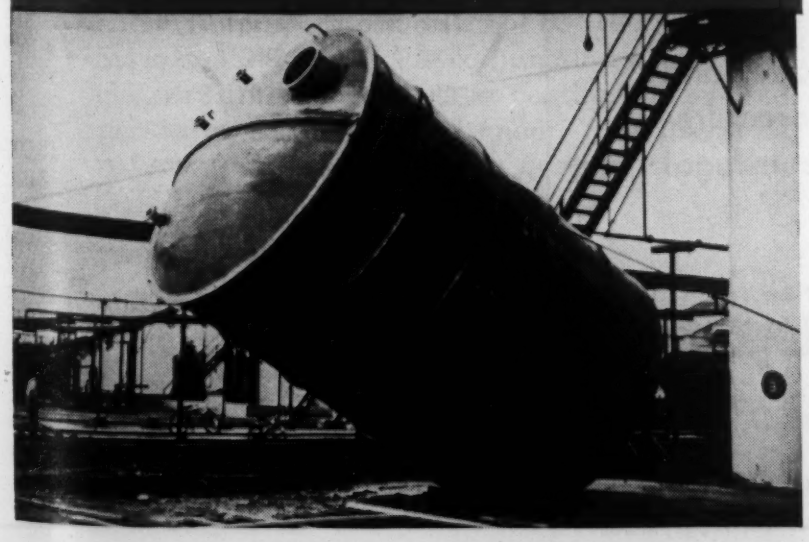


. . . extinguishes *its own flame after burning for only 35 sec.*

For more information, turn to Reader Service card, circle No. 423



LIGHT ENOUGH FOR HAND RIGGING, 12,000-gallon Haveg tank was installed in only 8 hours by two men . . . cost several thousand dollars less than conventional corrosion-resistant tanks. ▼



ATLAC® 382 POLYESTER

still OK after 2 years storing HCl

Corrosion-resisting assignments don't come much tougher than that filled by the storage tank shown here. Made by Haveg Industries, Inc., of Wilmington, Delaware using ATLAC 382 polyester resin, it has already racked up two years service for storing 37% hydrochloric acid.

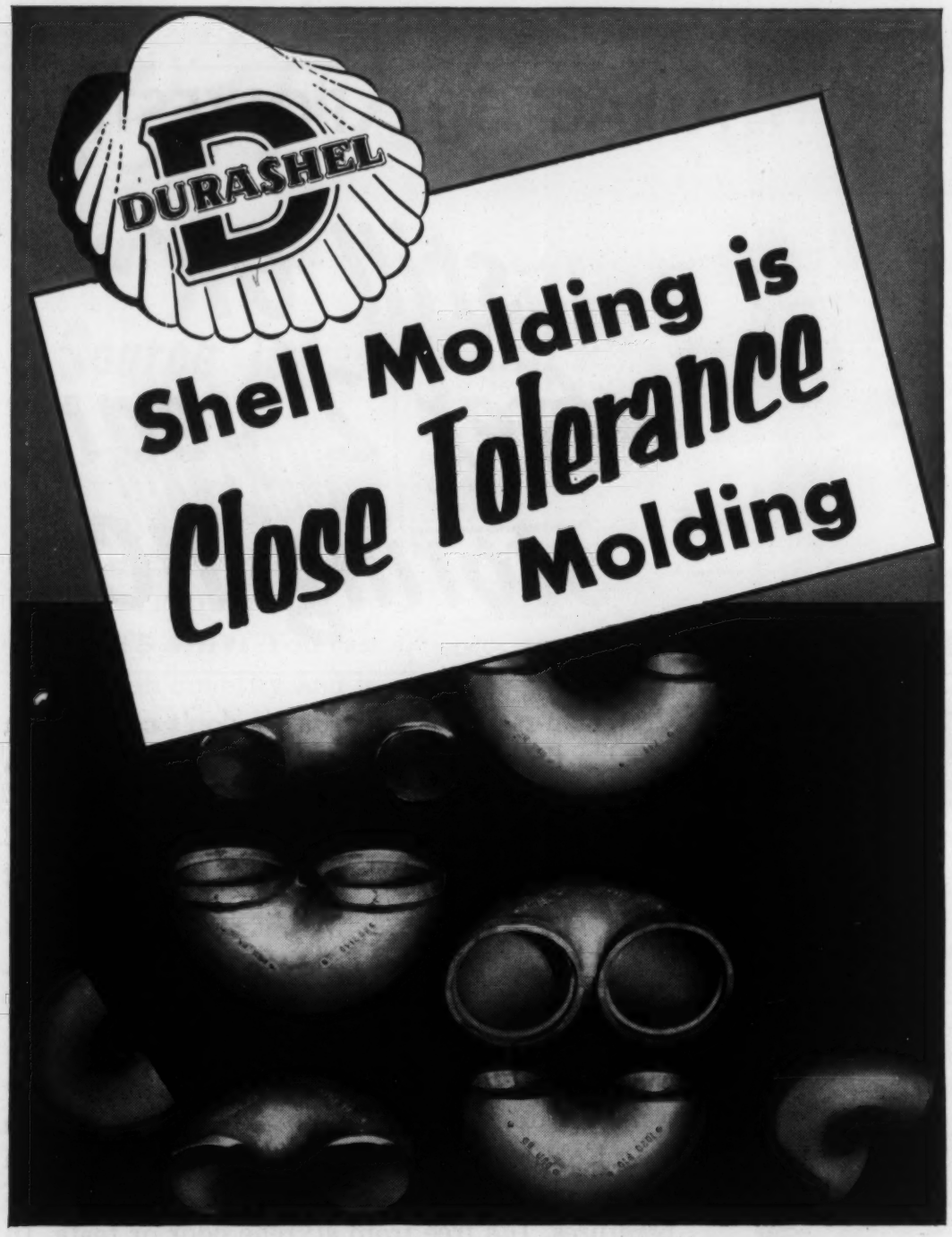
Superior resistance to acids, alkalies and detergents, even at high temperatures, is just one of the *different* qualities you get with ATLAC 382 . . . the *different* polyester. It's a high-strength, lightweight material that stays strong after exposure to steam or hot water. It keeps its high insulation resistance and low power factor at elevated temperatures. It's free from styrene odor or taste. In molding compounds, it carries fibers uniformly to edges, at corners and in deep draws.

ATLAC 382 comes in dry form for pre-pregs or for your own mixing, and in convenient new liquid form. Write today for complete data and samples.

CHEMICALS DIVISION
ATLAS POWDER COMPANY
WILMINGTON 99, DELAWARE
In Canada: Atlas Powder Company, Ltd.
Brantford, Ontario, Canada

Note: you can get the unusual qualities of ATLAC 382 in ready-to-mold form with our THERMAFLOW® reinforced molding compounds based on this *different* polyester.

For more information, turn to Reader Service card, circle No. 477



These are Duraloy Shell Molded 180° Bends. And incidentally, several different alloying combinations of chrome iron and nickel are represented in these bends.

One of the outstanding values in shell molded castings is the higher precision or close tolerance casting . . . also usually less machining and finishing . . . than when pieces are cast statically. For quantity production it is usually more economical.

We suggest that you investigate shell molding for your high alloy casting requirements. It has much to offer and we have complete facilities for taking care of your requirements. Should other casting methods—static or centrifugal be better, we have these facilities, too.

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 471

What's new IN MATERIALS

in cost with parts molded from general purpose glass-polyester compounds and substantially lower in cost than those molded from reinforced phenolic compounds having comparable strength.

Beryllium Oxide Parts Are Strong at 3500 F

Hot pressed and machined beryllium oxide shapes are now available from Beryllium Corp., Reading, Pa. for use at temperatures up to 3500 F. One of the most promising applications of the material is expected to be in the field of advanced nuclear reactors. Beryllium oxide has a neutron absorption cross section of 0.01, high thermal conductivity and excellent resistance to thermal shock.

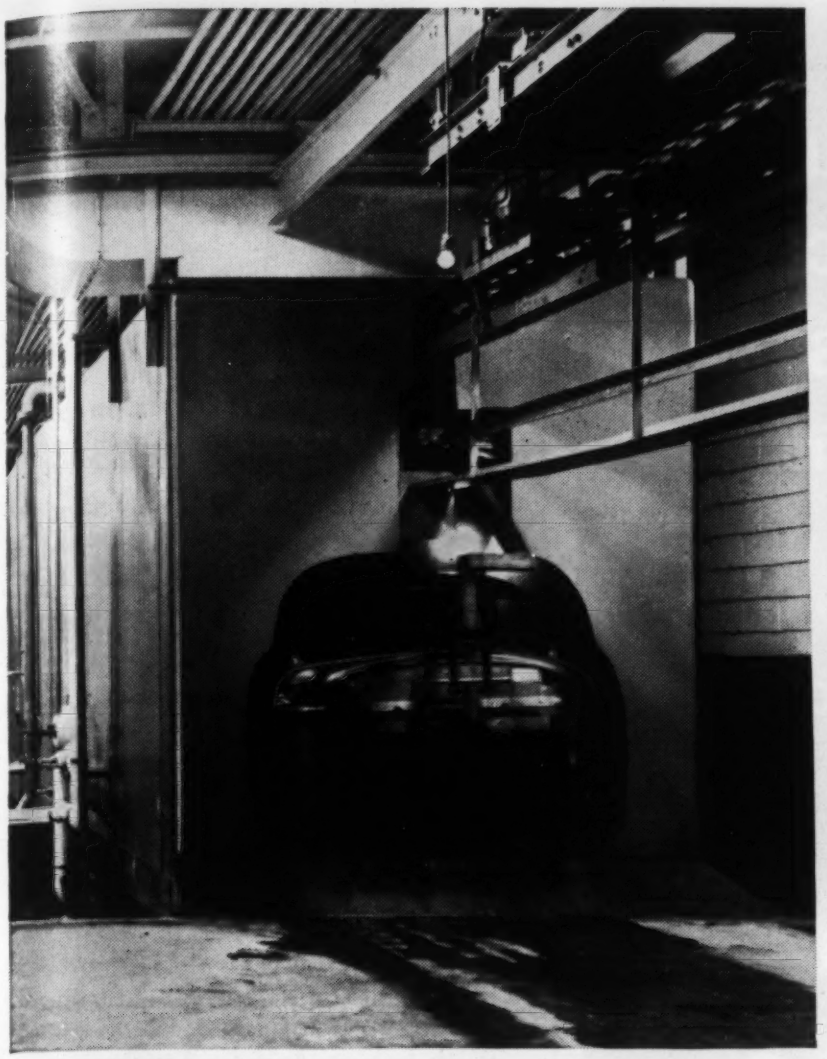
In the missile field, beryllium oxide shapes can be used for radiation windows and high temperature thermocouples. Electronic applications include Klystron and ceramic tube parts, antenna windows and airborne radar antennas. The shapes can also be used as crucibles for the melting of such metals as uranium, thorium and beryllium.

How shapes are made

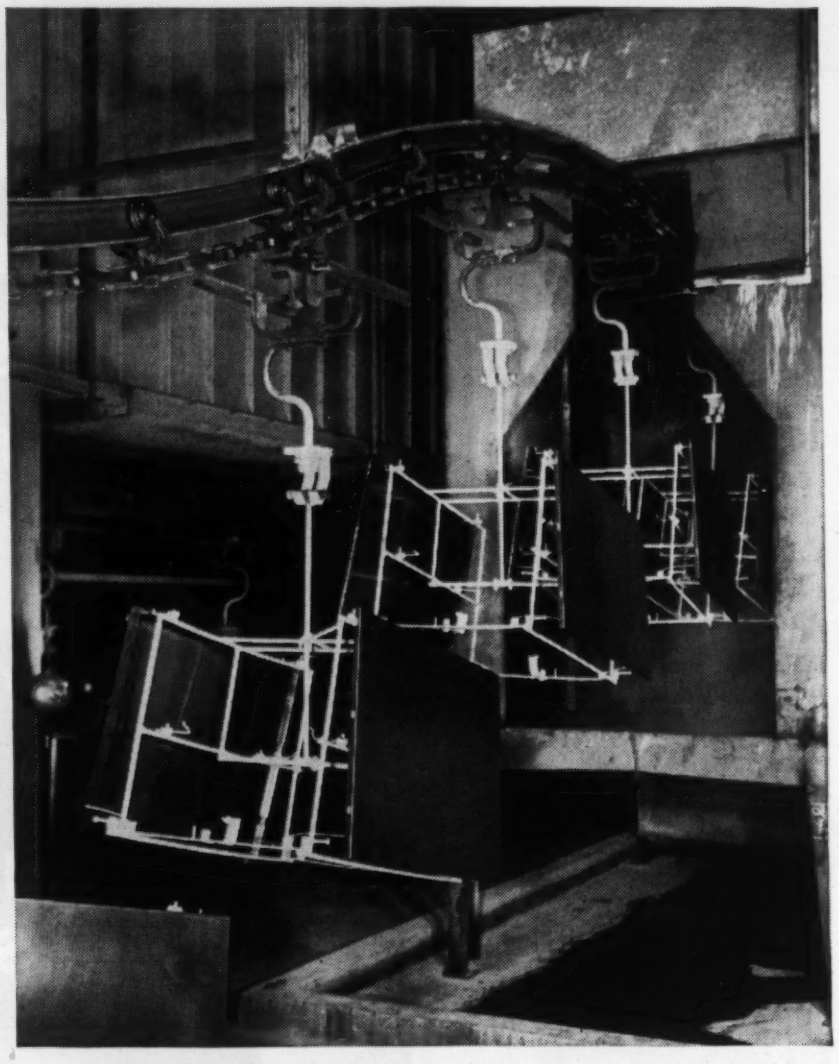
In the production of beryllium oxide shapes, high purity beryllium oxide powder is calcined from specially processed beryllium hydroxide at high temperatures. The powder is packed in graphite molds and hot

PROPERTIES OF BERYLLIUM OXIDE

PHYSICAL PROPERTIES	
Specific Gravity	3.025
Melting Point, F	4658
Ther Cond, Btu/hr/sq ft/°F/ft	100
Coef of Ther Exp, per °F	5.2×10^{-6}
MECHANICAL PROPERTIES	
Tensile Strength, psi	
Room Temp	15,000
2000 F	8,000
Compressive Strength, psi	
Room Temp	150,000
2000 F	60,000
Transverse Strength, psi	25,000
Modulus of Elasticity, psi	43×10^6
ELECTRICAL PROPERTIES	
Volume Resistivity, ohm-cm	
Room Temp	10^{16}
2000 F	10^{12}
Dielectric Constant (10^6 cps)	5.8



BODY LINES save up to 10 to 12¢ per body



APPLIANCE LINES save up to 4 to 5¢ per cabinet

New Parker COLD BONDERITE SYSTEM slashes steam costs!

Want to save up to 70% of heating costs on your phosphate coating line? Put in the amazing Cold Bonderite System, newly developed for low temperature operation.

It includes a new cold alkaline cleaner, specially developed to remove grease and soil through an effective temperature range of 60° to 120°. A new Spra Bonderite works in conjunction with the cold cleaner, producing excellent coatings at low temperatures. B.T.U. requirements are drastically reduced, with no sacrifice in quality.

Chemical costs of the new Cold Bonderite System just about match conventional cleaner and phosphating materials. Operation and control are simple as can be.

New Cold Bonderite System is at work right now—has been for months—in several famous production plants. It's a *proven* money-saver!

Find out how much Cold Bonderite System will cut *your* phosphate line heat costs. Write or call for complete information.

Since 1914— leader in the field

PARKER RUST PROOF COMPANY
2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

For more information, turn to Reader Service card, circle No. 485

SPECIALISTS IN COLD FINISHED STEELS EXCLUSIVELY

WYCKOFF STEEL COMPANY

General Offices: Gateway Center, Pittsburgh 30, Pa.

Branch Offices in Principal Cities

Works: Ambridge, Pa. • Chicago, Ill. • Newark, N. J. • Putnam, Conn.

WYCKOFF STEEL PRODUCTS: Carbon, Alloy and Leaded Steels • Turned and Polished Shafting • Turned and Ground Shafting • Large Squares • Wide Flats up to 12¾" x 2¼" and 14" x 1¼" • All Types of Furnace Treated Steels

For more information, turn to Reader Service card, circle No. 523

What's new IN MATERIALS

pressed in an induction furnace. After cooling, the beryllium oxide blocks are machined into desired shapes. Blocks up to 12 in. in height are now being produced by this technique.

Beryllium Corp. is conducting research to explore cold compacting, slip casting, extrusion and other techniques to reduce the cost of the finished pieces. Cold compacting and sintering are the methods presently used in the production of beryllium oxide crucibles.

Bright Silver Finish Is Hard and Ductile

A bright silver plating process that imparts a permanently hard, mirror finish (100% specular reflection) in both flash and heavy deposits, yet is reported to be faster and easier to use than other processes, is being put on the market by American Platinum & Silver Div., Engelhard Industries, Inc., 231 New Jersey Railroad Ave., Newark 5, N. J.

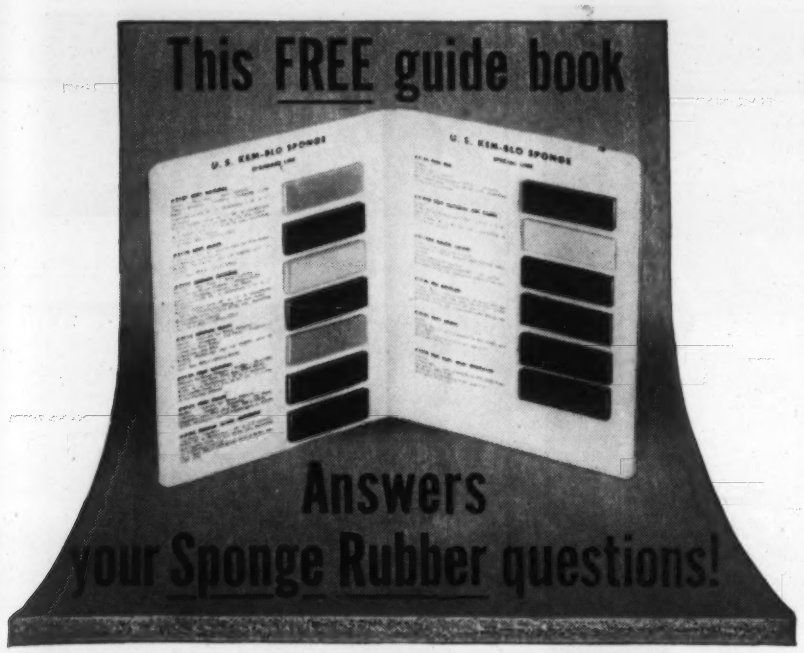
The company says the process, called Silva-Brite, has potential use for silver plating holloware, electronic and electrical parts, aircraft bearings, bus bars, waveguides and jewelry.

The process is said to give uniformly good results at current densities from 5 to 40 amp per sq ft. The solution's throwing power is described as excellent, affording more uniform thickness of deposits in blind holes and crevices.

Sonic Test Insures Quality of Laminates

A recent innovation at Glastic Corp. is the use of a sonic testing device to detect delaminations in its fiberglass-reinforced polyester laminates. (For details on a new fiberglass-polyester laminate made by the company see p 174 in this issue.)

Previously, sheet was examined for possible delaminations by a destructive test in which a sample was cut into many small pieces to allow visual inspection of the cut edges. Destructive testing, being expensive



Send today for this file-fitting folder and have 13 different actual Kem-Blo swatches at your finger tips. Kem-Blo is the perfect sponge rubber for your every job. Light . . . flexible . . . elastic . . . can be made to meet your specifications in various widths, compressions, shapes, and thicknesses. Choose from many colors, too! Write U. S. Kem-Blo Department.

U.S. Kem-Blo SPONGE

US RUBBER **United States Rubber**
Naugatuck, Conn.

If you want paper with
CONTROLLED
ABSORBENCY

MOSINEE

will make it to your
EXACT SPECIFICATIONS

for complete information write
MOSINEE
PAPER MILLS COMPANY
Mosinee, Wisconsin

For more information, turn to Reader Service card, circle No. 371

Your key to quality in
PLASTIC MOLDING

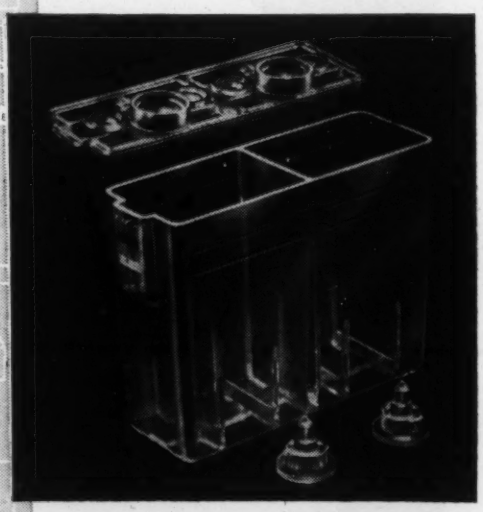
— complete custom service by
MACK MOLDING

MACK is one of the original plastic molders . . . offers industry-wide experience in design, mold making and choice of materials. High efficiency production methods and finishing assure economical, quality production. MACK engineers are available for consultation. They will recommend the best design for your product and the most efficient method of producing it. Estimates on your requirements will be made without obligation.

38 YEARS OF CUSTOM MOLDING TO INDUSTRY

Consult Mack engineers for assistance in solving your plastic molding problems —

- DESIGN ASSISTANCE
- MATERIALS SELECTION
- MODERN PRODUCTION METHODS
- MASTER TOOL MAKERS
- RIGID QUALITY CONTROLS



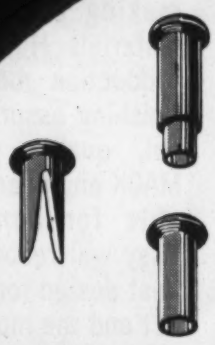
One of the many rugged battery cases molded by MACK

MACK
MOLDING CO • INC
General Offices and Main Plant:
WAYNE • NEW JERSEY

Other Plants located in
ARLINGTON, VERMONT and
WATERLOO, QUEBEC, CANADA

For more information, turn to Reader Service card, circle No. 437

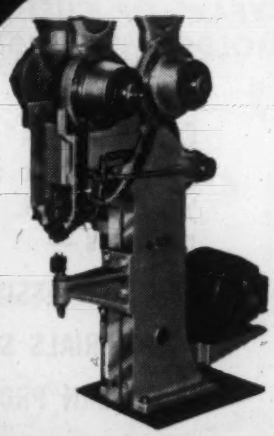
AT *Chicago Rivet* ALL 3
will reduce your Fastening Costs



rivets

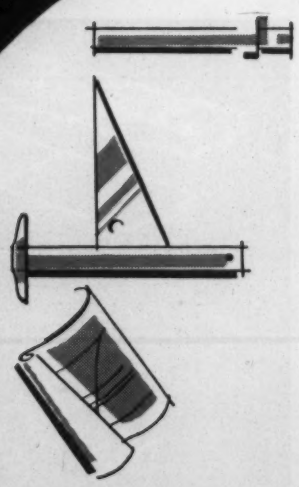
Semi-Tubular, Split and Shoulder

You avoid machine down-time because every semi-tubular, full tubular, split, shoulder or special rivet is precision made and hand inspected to assure free, non-clogging movement in automatic setters.



rivet setters

Your fastening costs are less because Chicago Rivet makes machines that set from one to seven rivets at a time. Riveting is automatic and may involve the use of special indexing fixtures, adjustable riveting centers, and top or bottom rivet feeding and other mechanisms, controlled by solenoids or air cylinders or both.



engineering

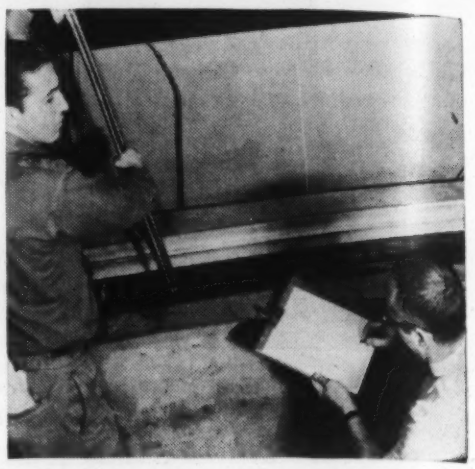
The recommendations of Chicago Rivet Engineers are most valuable. Their knowledge of rivet fastening techniques, gained from solving thousands of manufacturers' fastening problems can help make your product more competitive. Calling Chicago Rivet is a habit-formed procedure with many companies. You incur no obligation when you use the service of Chicago Rivet Engineers. Send a blue print or sample assembly with your inquiry.

Chicago Rivet & MACHINE CO.
9628 WEST JACKSON BOULEVARD
BELLWOOD (CHICAGO SUBURB) ILLINOIS
BRANCH FACTORY: TYRONE, PA.

New Rivet Catalog contains engineering data, list of popular semi-tubular, full tubular, split and shoulder rivets and popular automatic rivet setters. Write for copy.

For more information, turn to Reader Service card, circle No. 431

What's new IN MATERIALS



***Polyester laminate** is sonic tested for delaminations.*

in both labor and material, only allowed spot inspection.

In the sonic testing operation, sheets are lifted by an overhead crane and placed in a tank of water. A sonic tester's transmitting and receiving crystals, mounted on long rods, are placed at opposite sides of the sheet. As an operator moves the crystals over the surface of the sheet the sound waves generated by the transmitting crystal are picked up in the receiving crystal. A meter indicates any variation in the sound waves. A low reading indicates the presence of a delamination.

According to Glastic, the transmitting and receiving crystals of the sonic tester are so sensitive that the location of a delamination can be determined to within ½ in. of its exact position.

Insulations Made of Metals, Refractories

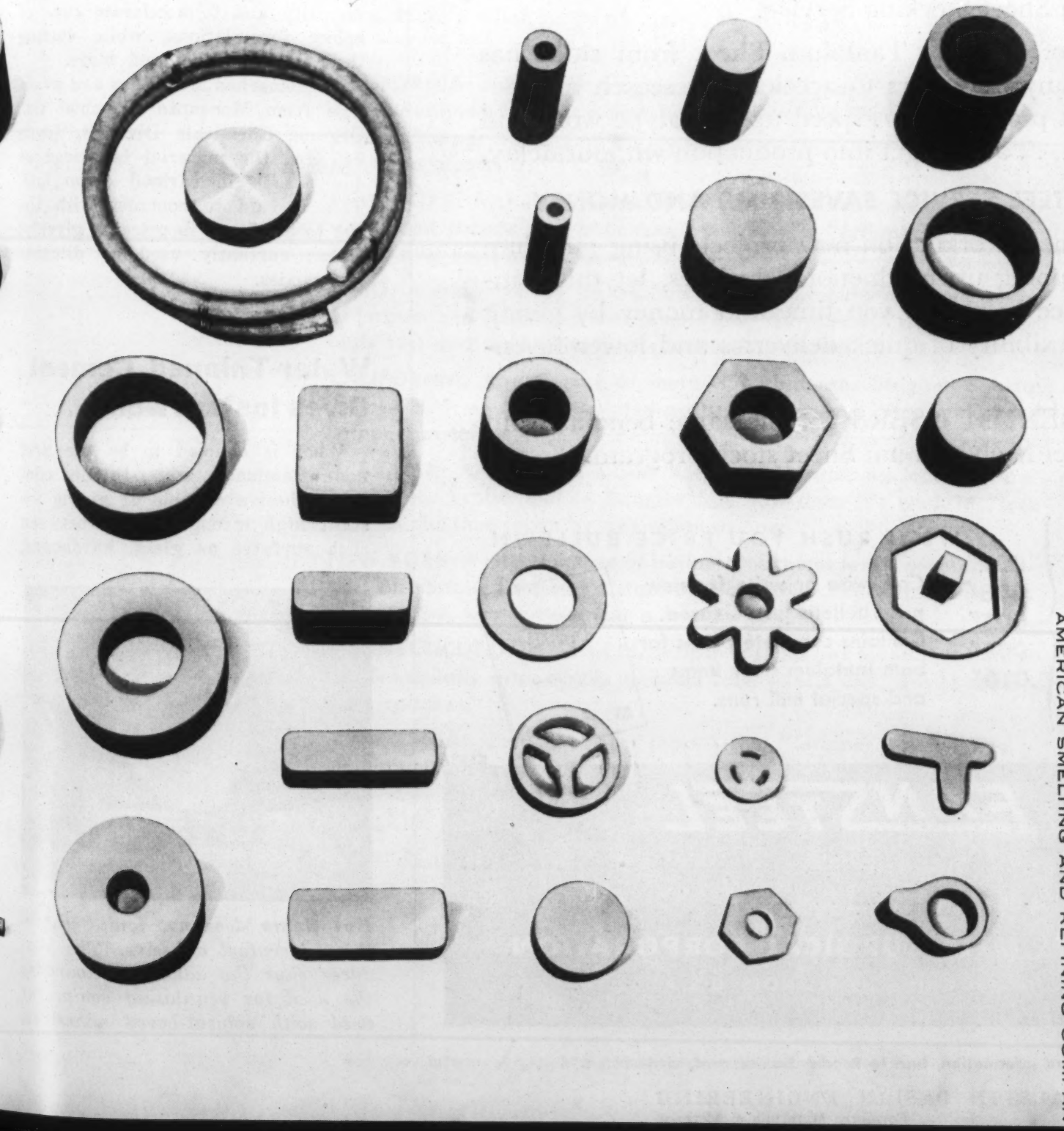
A line of industrial thermal insulations custom-made from refractory fiber felt encased in a thin metal foil or mesh such as aluminum, stainless steel or titanium is now available from Johns-Manville, 22 E. 40th St., New York 16. The insulations, called Pre-Klad and supplied as blankets and housings, are designed for service at temperatures up to 2000 F.

Recommended applications for Pre-Klad insulations include gasoline engines, gas turbines, high temperature valves and fittings, steam turbines, heated mechanical equipment,

For more information, circle No. 413 ➤

In continuous lengths: the bronze casting you want in the shape you want! The advantages of custom-shapes in long lengths instead of individual castings. The uniformity and machinability of bronze alloys with no hard or soft spots: no sand, dirt, or dross to dull tools or reduce cutting speeds. The superior physical characteristics of continuous cast bronzes: impact, tensile, and yield strength, and hardness, improved as much as 100% over the same alloys cast by other methods. Asarco will custom cast practically all standard tin-bronze alloys in the shapes, lengths and diameters you need. Asarcon 773 (SAE 660), general purpose bearing bronze, is available from stock in 260 standard sizes, solids and tubes. Check with your local Asarco distributor or write: Continuous-Cast Products Dept., American Smelting and Refining Company, Barber, N. J., Kingwell Bros., Ltd., 457 Minna St., San Francisco. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

CONTINUOUS-CAST DEPARTMENT OF



ASARCO

AMERICAN SMELTING AND REFINING COMPANY

TANTALUM Sheet FROM STOCK

"As fast . . . as dependable as requisitioning from our own stock room." That's what hundreds of firms say about the Fansteel Tantalum Sheet Stocking Service.

Delivery of Fansteel Tantalum Sheet from stock has helped many customers to accelerate research and development programs . . . speed up prototype work and pilot runs . . . and to get into production without delay.

FANSTEEL SERVICE SAVES TIME AND MONEY

If you're now working on new projects using tantalum or are stepping up production schedules, let this Fansteel Service help save you time and money by giving you the flexibility of quick deliveries and lower inventory costs.

MOLYBDENUM USERS get the same benefits from the Fansteel Molybdenum Sheet stock program.

IMMEDIATE DELIVERY ON THESE FIVE MOST USED SIZES OF TANTALUM SHEET

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.003″
.005″
.007″
.010″

WE'LL RUSH YOU PRICE BULLETIN

Call, wire or write for new price bulletin just released. Contains complete prices for both tantalum stock items and special mill runs.

K588A

FANSTEEL®

FANSTEEL METALLURGICAL CORPORATION

NORTH CHICAGO, ILLINOIS, U. S. A.

For more information, turn to Reader Service card, circle No. 511

What's new IN MATERIALS

domestic and industrial furnaces, stress relieving blankets, ingot pads and heated laboratory equipment. Other possible uses: furnace nozzle cones, removable casting and forging covers, gear housings, railroad rolling equipment, material handling equipment, turbo-generators, portable heat retention equipment, home incinerators and dryers.

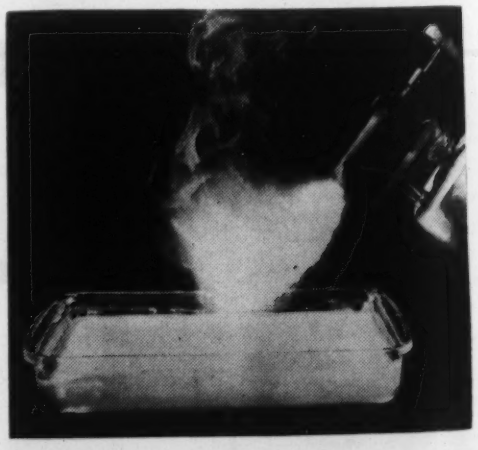
Improved Epoxies

Lost cost epoxy parts with improved physical and electrical properties can be obtained by using an organophosphorous modifier. The modifier is said to impart low initial viscosity and to accelerate cure of epoxy formulations, while cutting their cost by 20% and more.

Trademarked Mod-Epox and available from Monsanto Chemical Co., Organic Chemicals Div., St. Louis 24, Mo., the material is priced at 46¢ per lb in carload drum lots. This is said to contrast with the 80¢ to $1.25 per lb price of glycidyl ethers currently used as diluents for epoxies.

Water-Thinned Cement Gives Instant Bond

What is claimed to be the first non-inflammable, water-thinned contact adhesive capable of giving instant high strength bonds between such surfaces as glass, hardboard,



***Hot flame** does not ignite water-thinned contact adhesive. The producer says the adhesive eliminates the need for ventilating equipment used with solvent-based adhesives.*

Don't throw away those epoxy-coated rejects

Here's a new paint stripper that will save them

Do you scrap perfect metal parts that have been imperfectly coated with epoxies, vinyls, polyesters and other hard-to-strip paints or lacquers?

In the last few months, users of Oakite Stripper S-A have eliminated many such losses. Here's what some of them say about it:

CALIFORNIA: An aircraft manufacturer tested many strippers on an epoxy designed to resist attack by hydraulic fluid. Finally found that Oakite Stripper S-A is "the only one that safely strips this paint from anodized aluminum."

NEW YORK: A camera maker coats flash bulb reflectors with black vinyl paint outside and aluminum paint inside. "Stripper S-A is the fastest ever used on our rejects."

OHIO: A maker of toy pistols had trouble stripping alternate coats of lacquer and metallized aluminum. Now "Stripper S-A does it amazingly fast and remetallizing is completely satisfactory."

CALIFORNIA: A producer of metal furniture uses Stripper S-A to remove clear epoxy from plated parts. Chemist says "This is the best stripper on the market."

ALABAMA: A hardware maker had trouble stripping lacquer from brass door knobs. Oakite Stripper S-A now does the work in "less than ⅓ the time taken by any other stripper."

NEW YORK: A manufacturer of business machines tested several strippers on various finishes on steel and aluminum. Verdict in favor of Stripper S-A was: "It's doing a wonderful job."

CONNECTICUT: A maker of brass lipstick shells has found that "Stripper S-A quickly strips epoxy lacquers from rejects and heavily coated work spindles."

CALIFORNIA: A missile maker reports that "Stripper S-A is doing a fine job stripping vinyl from stainless steel and titanium."

FREE Write Oakite Products, Inc., 40 Rector St., New York 6, N. Y., for complete information on Oakite Stripper S-A.

In our 50th year.

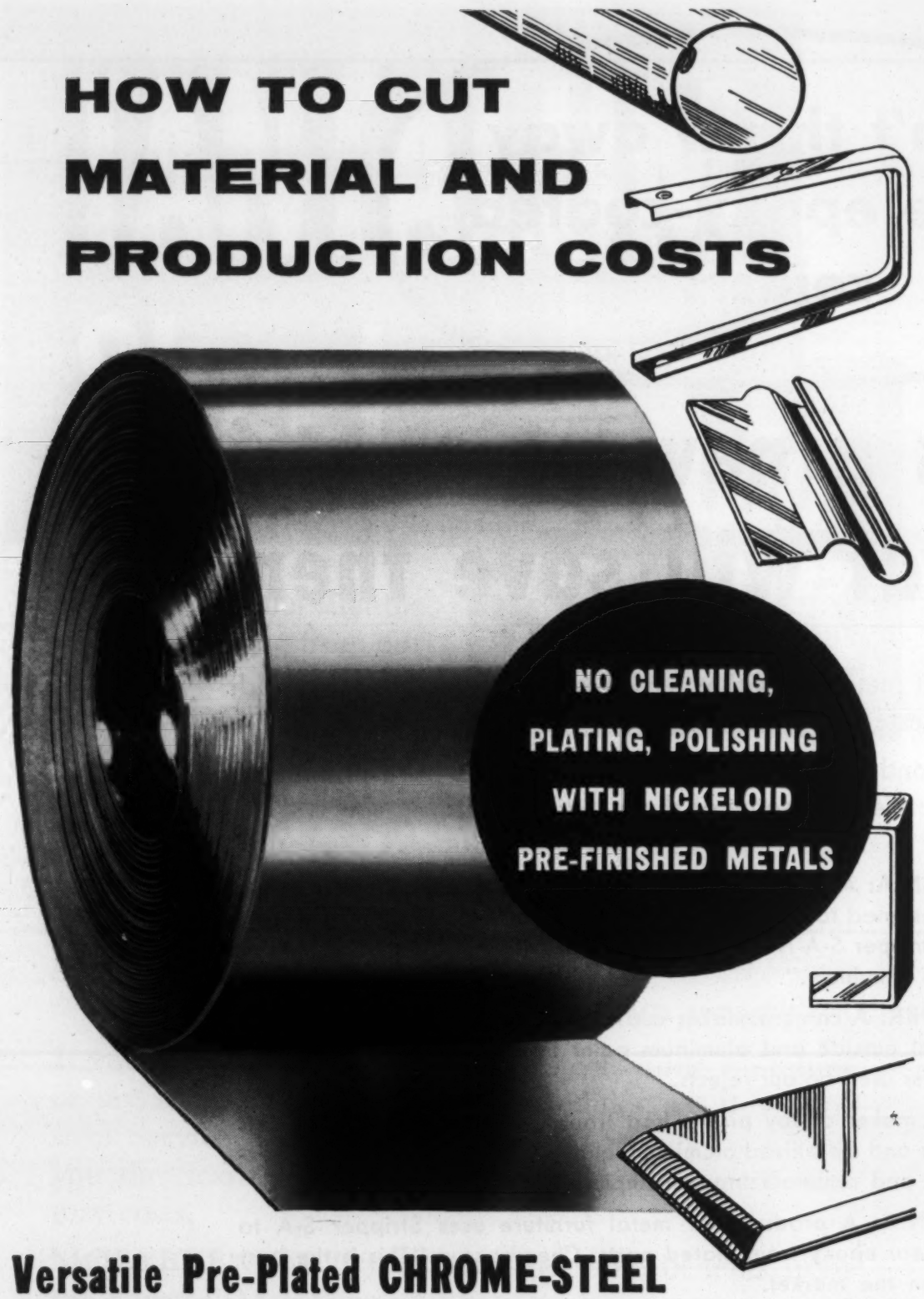
SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

Technical Service Representatives in Principal Cities of U. S. and Canada

Export Division Cable Address: Oakite

For more information, turn to Reader Service card, circle No. 419

HOW TO CUT MATERIAL AND PRODUCTION COSTS



Versatile Pre-Plated CHROME-STEEL and NICKEL-STEEL Now Available in Three Grades

Cut costs! — Reduce production steps! The *need* was never greater; the *method* never surer than with Nickeloid chrome-steel and nickel-steel . . . now available in C-grade, *a new low-cost utility grade* for applications that don't require the quality of our A and B grades. These cost-cutting design materials are *pre-finished* — eliminate extra handling, cleaning, racking and polishing costs, plus actual plating costs. So versatile — adaptable to standard production methods, too! Their beautiful durable finishes can add so much in sales and utility value to your products at very low cost. Cut costs, reduce production steps with Nickeloid chrome-steel or nickel-steel — big 24" wide coils, sheets, strips; bright and satin finishes. Now save even more with new low-cost C-grade!

NICKELOID METALS SINCE 1898 NM

Write For More Information

AMERICAN NICKELOID COMPANY

PERU 6, ILLINOIS

MILLS — Peru, Illinois and Walnutport, Pennsylvania Sales Offices Throughout the U.S.A.

For more information, turn to Reader Service card, circle No. 461

What's new IN MATERIALS

metal, plastics and wood has been introduced by National Starch Products, Inc., Structural Products Div., 270 Madison Ave., New York 16.

Marketed as Instant-Lok 4300, the adhesive is said to possess the instant bonding properties usually associated with solvent-based adhesives. National says the cement can be used in bonding almost any structural material and is therefore expected to find use in the woodworking, furniture, construction and electronics industries.

Other News . . .

Ferrous metals

▸ Thin-walled, welded stainless and carbon steel tubing in diameters from ¼ to 1½ in. o.d. and in wall thicknesses from 0.005 to 0.020 in. is now available from Universal Tube Corp., 2133 S. Kedzie Ave., Chicago 23. The tubing is also available in brass and bronze.

▸ Coated steel wire grilles in a variety of patterns, designs and finishes are commercially available from F. P. Smith Co., 2340 N. Clybourn Ave., Chicago. Called MetaLoom, the grilles are also available in brass.

Nonferrous metals

▸ A self-lubricating bronze bearing, a product of Booker-Cooper, Inc., 6940 Farmdale Ave., North Hollywood, Calif., has been developed for small sealed assemblies. The bronze bearing is called Sinite-D-5-S.

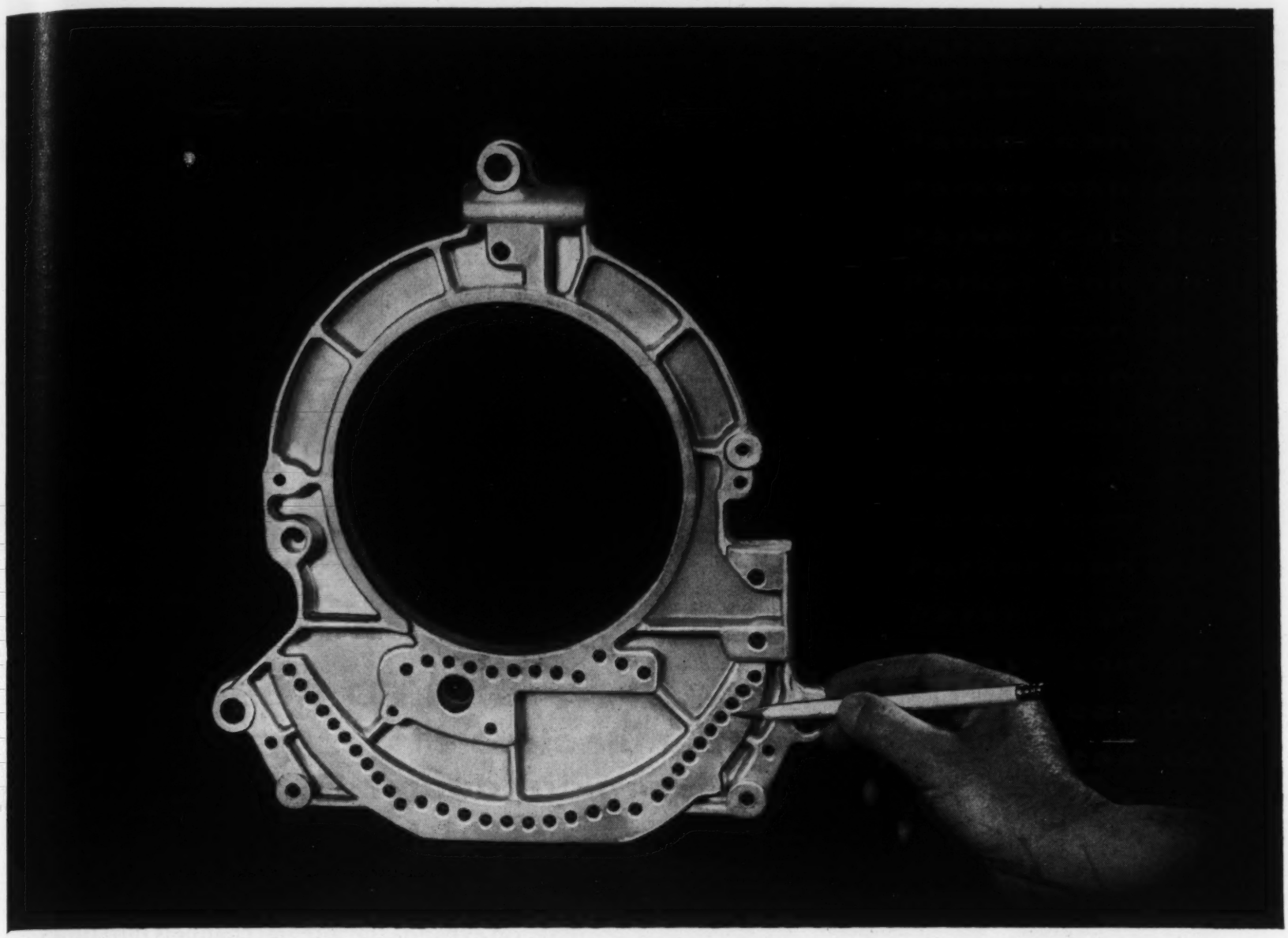
▸ A silicon-aluminum alloy (containing over 20% silicon) is being evaluated by Aluminum Co. of America, 740 Alcoa Bldg., Pittsburgh 19 for such wear resistant applications as automobile engines. Alcoa says recently developed foundry techniques and improved cutting tools make it possible to cast and machine the superhard alloy with comparative ease.

Plastics and rubber

▸ A new process developed by Lowe Paper Co., Ridgefield, N. J. is said to permit gluing of polyethylene-coated paper with inexpensive dextrin and starch adhesives.

▸ Linear polyethylene sheets are now available in sizes of 40 x 72 in. and in thicknesses from 0.020 to 0.125 in. Called Midlon Lp, the sheets are sup-

(continued on p 188)



The WHOLE Story Of Die Casting Savings

PARKER SALES ENGINEERS

BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street

CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street

DAYTON 4, Ohio
William C. Twiss • 915 Valley Street

DETROIT 35, Mich.
Hodgson-Geisler Co. • 18917 James Couzens

GIRARD, Penna.
Daniel F. Marsh • 35 Chestnut Street

LONG BEACH 11, California
R. W. Fletcher • 2803 Loomis Avenue

MINNEAPOLIS 16, Minn.
O. R. Kreutziger • 6524 Walker Street

PHOENIX, Arizona
Fred B. Larsen • 6108 North 11 Avenue

ST. LOUIS 8, Mo.
Frank May • 4378 Lindell Boulevard

SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.

WILTON, Conn.
Girard L. Palmer • Belden Hill Road

WINTER PARK, Florida
Duane P. Davis • 110 South Orlando Avenue
Box 26

These close tolerance holes could have cost more than the part itself. Actually, *they cost practically nothing!* Parker-engineered die casting makes the difference. By means of precision coring, the holes are cast to exact diameter and location . . . a bonus in the low unit cost of producing the complete part. Just think of the savings compared with other production methods requiring finish machining.

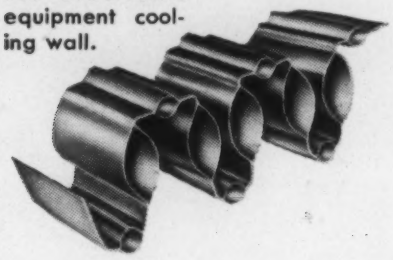
The creative engineering approach that made these savings possible has been the hallmark of Parker service since 1906. It is the plus factor that is never figured into a Parker estimate. If you are a Parker customer, you know this is so. If you are not, you can profitably prove it to yourself by consulting the nearest Parker sales engineer on your next component part requirement.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

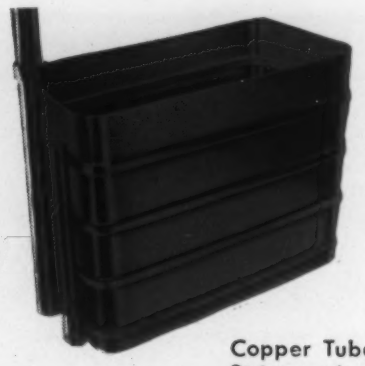
PARKER

high pressure die castings in ALUMINUM • ZINC POWDERED METAL PARTS

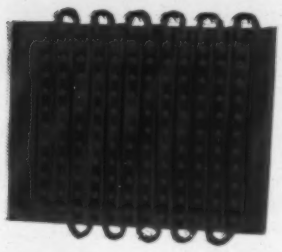
For more information, turn to Reader Service Card, circle No. 454



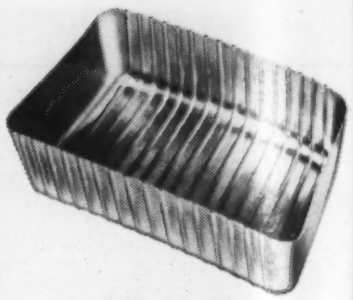
Section of Aluminum Tube-In-Strip combining refrigerant passages with air cooling for electronic equipment cooling wall.



Copper Tube-In-Strip used as a combustion chamber for water heater.



Copper Tube-In-Strip with return bends attached to produce a cooling plate.



This electronic cooling case of Revere Aluminum Tube-In-Strip was inflated after drawing.

REVERE *Tube-In-Strip* SCORES

NOW USED AS WATER-COOLED BUS BAR in manufacture of General Electric Semiconductor Rectifiers

HAS THESE 4 BIG MONEY-SAVING ADVANTAGES

1 Because it is a homogeneous mass Revere Tube-In-Strip eliminates the possibility of leaks.

2 User is able to obtain more efficient cooling.

3 If user finds it necessary to change cells it can be done without draining the system.

4 Revere Tube-In-Strip enables user to have a completely sealed system, thus eliminating O-rings or gaskets.

The use, by General Electric, of Revere Tube-In-Strip as water-cooled bus bar is still another of the myriads of ways this revolutionary product can be applied in industry.

The unique thing about Revere Tube-In-Strip is that it is a solid piece of metal, not two strips welded, brazed or bonded together. You buy strip, fabricate it as you wish, stamping, bending or forming it, and then as a final operation inflation expands the integral channels into tubes. Expanding in the open, the tubes are round; by expanding into dies, the tubes can be made rectangular, fluted, half-round, hexagonal, etc.

Revere Tube-In-Strip saves on first cost, and in fabrication. New and improved designs are made possible. The web between the tubes conducts heat faster. The vastly increased structural strength means you can use lighter gauges, saving in weight and price.

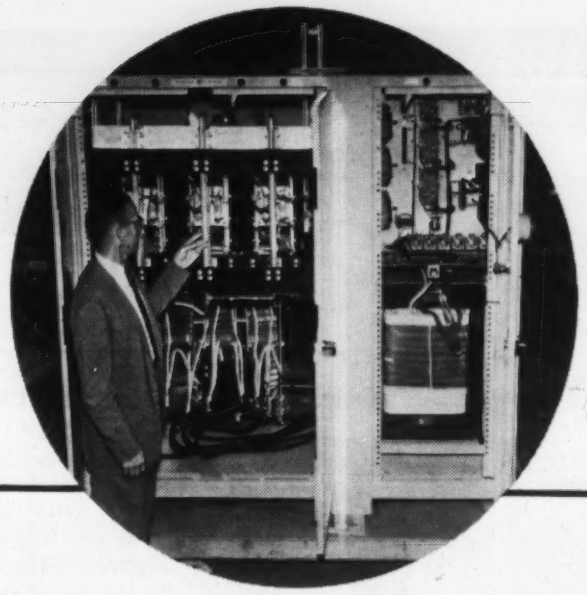
Revere Tube-In-Strip is available in Copper, Copper-base alloys and Aluminum alloys. The Revere Technical Advisory Service and the Research and Development Department will gladly collaborate with you in taking full advantage of this marvelous new material.

REVERE COPPER AND BRASS INCORPORATED

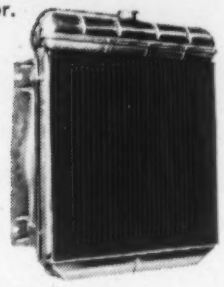
Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.

Mills: Rome, N. Y.; Baltimore, Md.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; Ft. Calhoun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

Copper Tube-In-Strip spiral containing both water and refrigerant passages for increased cooling efficiency.



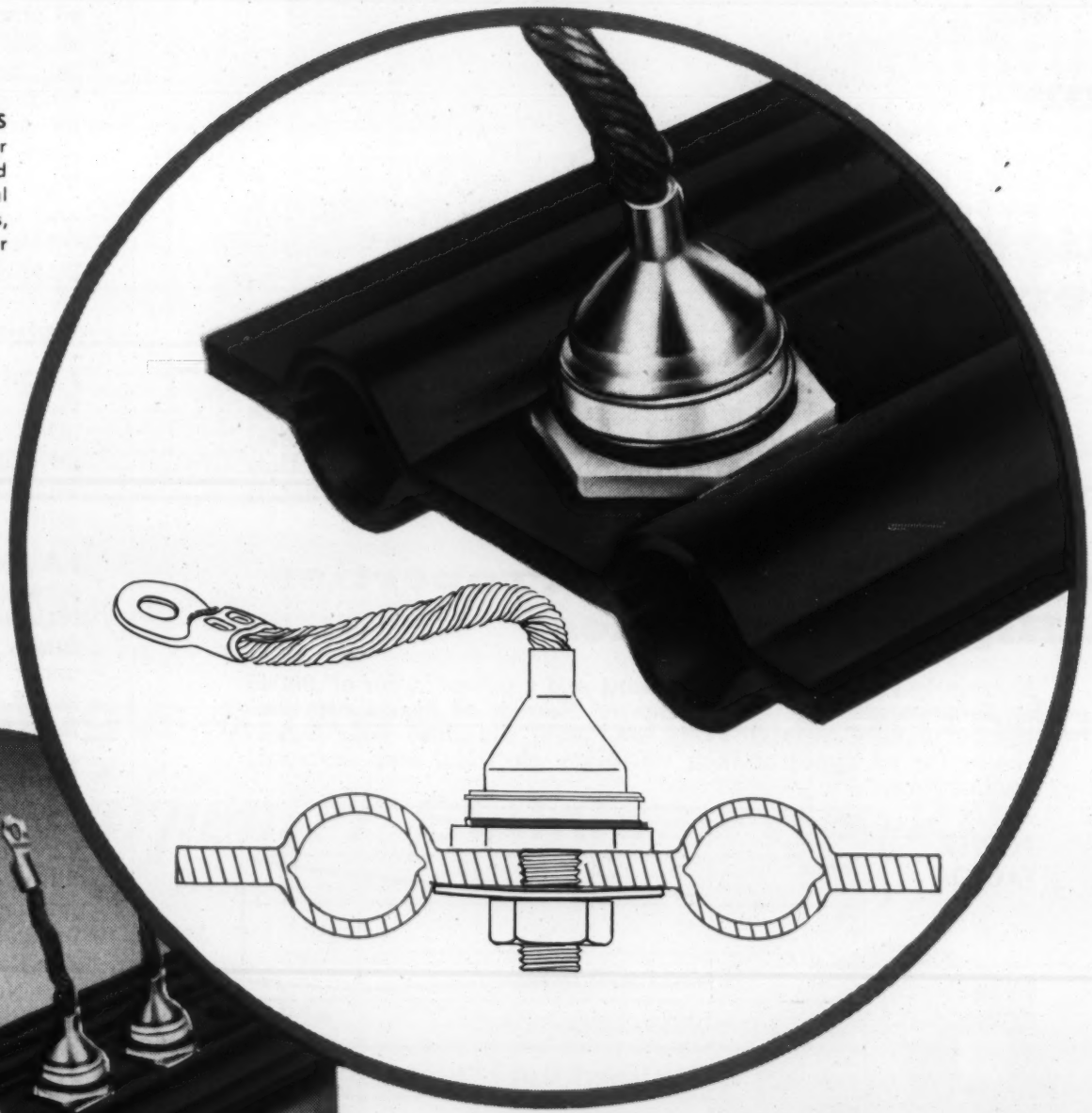
Copper Tube-In-Strip and copper fin assembly for automobile radiator.

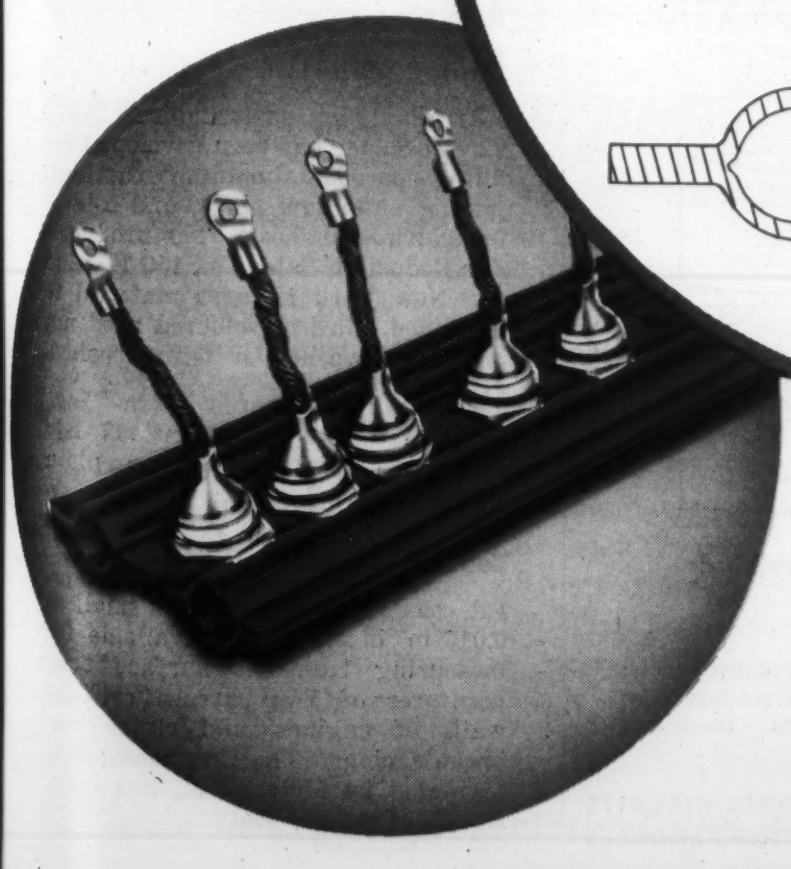


Copper Tube-In-Strip and finned stock assembled and then inflated into automotive air conditioning coil.

ANOTHER TRIUMPH!

PHOTO IN CIRCLE ABOVE SHOWS water-cooled semiconductor power rectifier design with integrally mounted transformer as made by General Electric Company. Rated 150 volts, 4000 amps., d-c, it is used for copper refining.





(*Above*) **CROSS SECTION** of water-cooled bus, featuring improved cooling method. Dual, leak-proof water passages are formed in solid bus, made from Revere Tube-In-Strip, without the need for welding or brazing. They are located on each side of a section of bus to which silicon cells can be bolted without penetrating the coolant passages.

(*Left*) **OVERALL VIEW** of new sealed liquid-cooled bus illustrating manner of mounting several silicon rectifier cells. Unique "dry" mounting permits installation of cells without draining liquid from bus. Cells are individually attached to the bus with threaded stud and nut, simplifying the mounting of a cell, and making it unnecessary to disturb any of the other cells on the bus.

For more information, turn to Reader Service card, circle No. 529

Long Kiln–Short Delivery

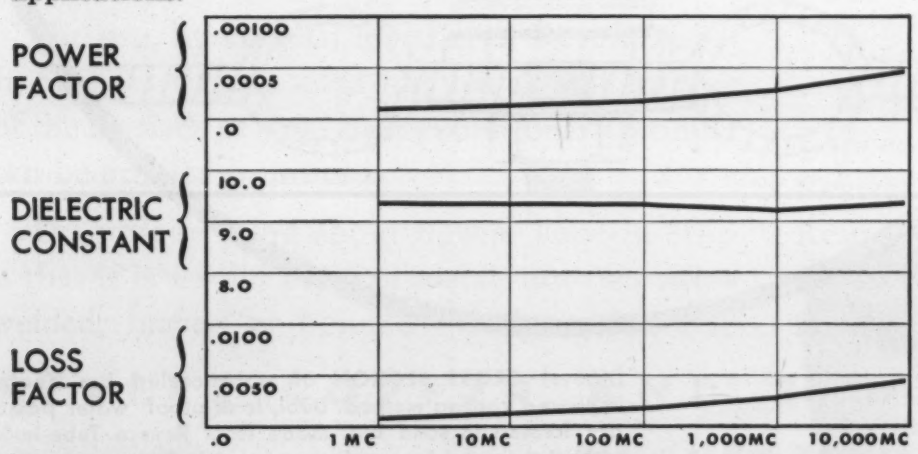
for Centralab®

High Alumina Ceramics

Fast delivery of 95% and 85% High Alumina, to your most critical specifications, is assured by Centralab's new 80 foot continuous kiln. First of its design in the United States, this new kiln is capable of producing 21 tons of exceptional quality High Alumina every month. Consistent reproduction of electrical and physical properties from batch to batch is guaranteed.

Superior Electrical Properties at High Frequencies

Extremely stable dielectric constant and a power factor of .00045 at 9000 megacycles (see graphs of Bureau of Standards tests below) make Centralab Body 206 (95% alumina) your logical choice for all types of high reliability electrical and electronic applications.



For complete specifications and design data write Centralab or consult Sweet's Product Design File (folio 4 a/ce).

Centralab®

X-5830

A DIVISION OF GLOBE-UNION, INC.
946L E. KEEFE AVE. • MILWAUKEE 1, WIS.
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VARIABLE RESISTORS • SWITCHES • PACKAGED ELECTRONIC CIRCUITS
CERAMIC CAPACITORS • ENGINEERED CERAMICS • SEMI-CONDUCTOR PRODUCTS

For more information, turn to Reader Service Card, circle No. 425

What's new IN MATERIALS

Other News—cont'd from p 184

plied by Midwest Plastic Products Co., 1801 Chicago Rd., Chicago Heights, Ill.

▸ An improved vinyl-glass insulating sleeving has been brought out by Bently, Harris Mfg. Co., Conshohocken, Pa. to meet nearly all Class A and Class B insulating requirements. It is made in three grades.

Other nonmetallics

▸ Ceramic blocks and machined shapes for model making, experimental designs, research, and work-holding devices are being supplied by American Lava Corp., Cherokee Blvd. & Mfrs. Rd., Chattanooga 5, Tenn. The producer says physical and electrical characteristics of the ceramic blocks and shapes are very little changed after firing.

Finishes

▸ A silver paint used for printed circuits on ceramics, glass, mica and other inorganic materials has been developed by Western Gold & Platinum Co., Belmont, Calif. The paint contains finely divided glass particles.

▸ A peelable plastics coating for temporary protection of nonporous materials against corrosion, chemical fumes and abrasion is marketed under the name Peel-It Weatherguard by Harco Chemical Co., Cranford, N. J.

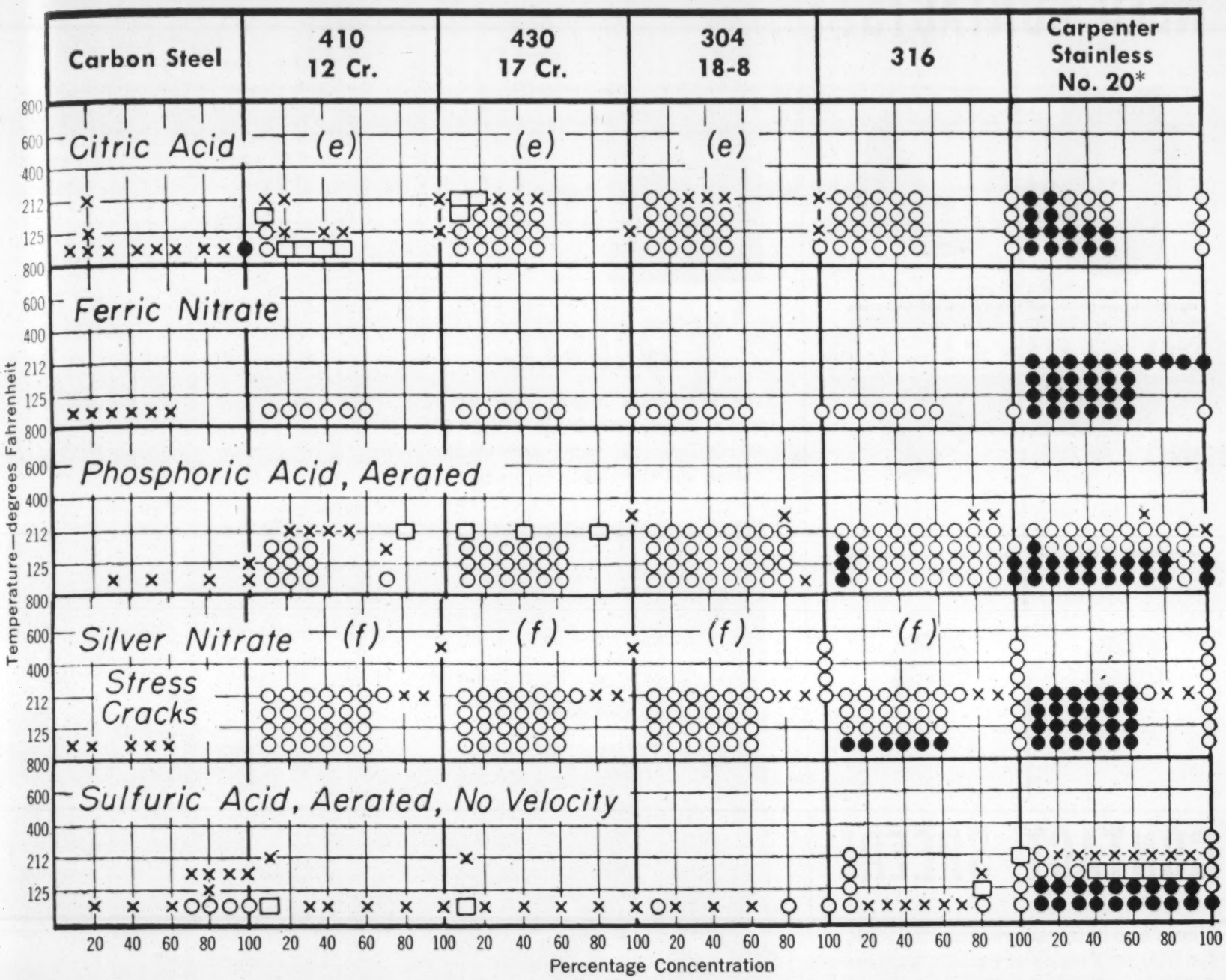
Joining materials

▸ An aluminum soldering rod called 720 Al-Solder has been developed for filling porous aluminum castings, joining aluminum parts, and soldering galvanized sheets. The producer, Air Reduction Sales Co., 150 E. 42nd St., New York 17, says material to be joined, filled or soldered need not be fluxed, washed or wire brushed.

▸ American Standards Assn. Inc., 70 E. 45th St., New York 17 has revised Standard B27.2 on plain washers.

Testing equipment

▸ A coaxial thermocouple as small as 0.015 in. in dia is now available for measuring transient surface temperatures of gun barrels, cylinder walls of engines, and clutch and brake facings. The thermocouple is marketed by Motech Co., Box 6009, Kansas City 10, Mo.



Key: ● Corrosion rate less than 2 m p y ✕ Corrosion rate greater than 50 m p y
○ Corrosion rate less than 20 m p y (e) Avoid chlorides
□ Corrosion rate from 20 to 50 m p y (f) Acid free

Corrosion data taken from Metals Handbook

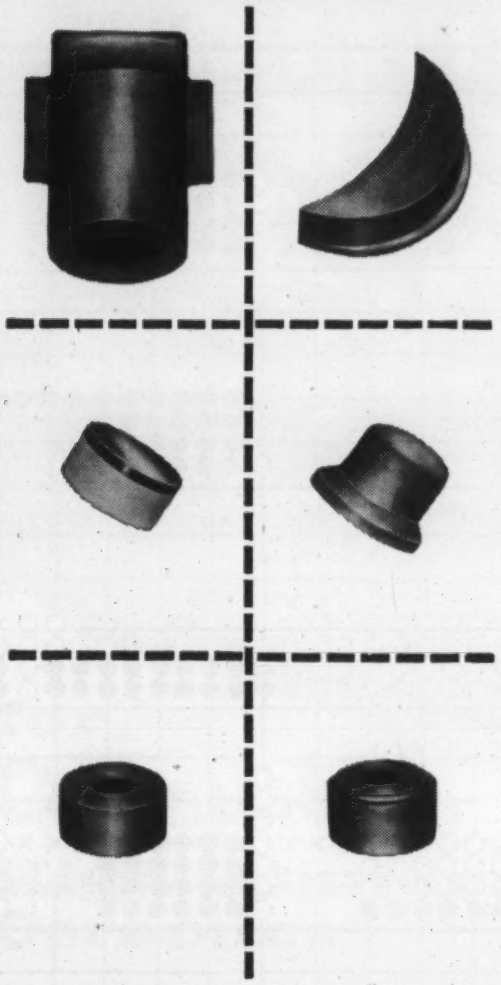
The best single answer to most corrosion problems—*Carpenter* Stainless No. 20*

Carpenter Stainless No. 20 is your lowest cost way to control the most severe corrosive conditions. It's available in sheet, plate, bar, forging billets, forgings, tubing and pipe through your local distributor. And Carpenter Stainless No. 20 simplifies inventory problems. You don't need duplicate stocks of other products . . . one stock of Carpenter Stainless No. 20 will put an end to most corrosion problems. Order now from the "House of Corrosion Control". Complete technical data and job performance reports are yours for the asking. Write on your company letterhead to The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

available through representatives and distributors in over 40 cities . . . coast to coast

For more information, turn to Reader Service card, circle No. 480

NEED CONTACTS?



CONTACT SPEER!

There's no better source than SPEER for Contacts made of carbon, copper-graphite or silver-graphite. Why? Because nobody knows *more* about carbon and graphite than SPEER. SPEER Contacts are available in solid button types, solid types with shunts, rectangular flats, special-shape flats and other special shapes. All are uniformly made of the finest materials, perfectly shaped, and exhaustively tested. In scores of different applications, SPEER Contacts will serve you better and longer. That's why, if you have a contact to make—contact SPEER!

SPEER Carbon Co. St. Marys, Pa.

I WANT TO KNOW how SPEER Contacts give longer life and save on maintenance. Please send information to:

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

For more information, circle No. 467

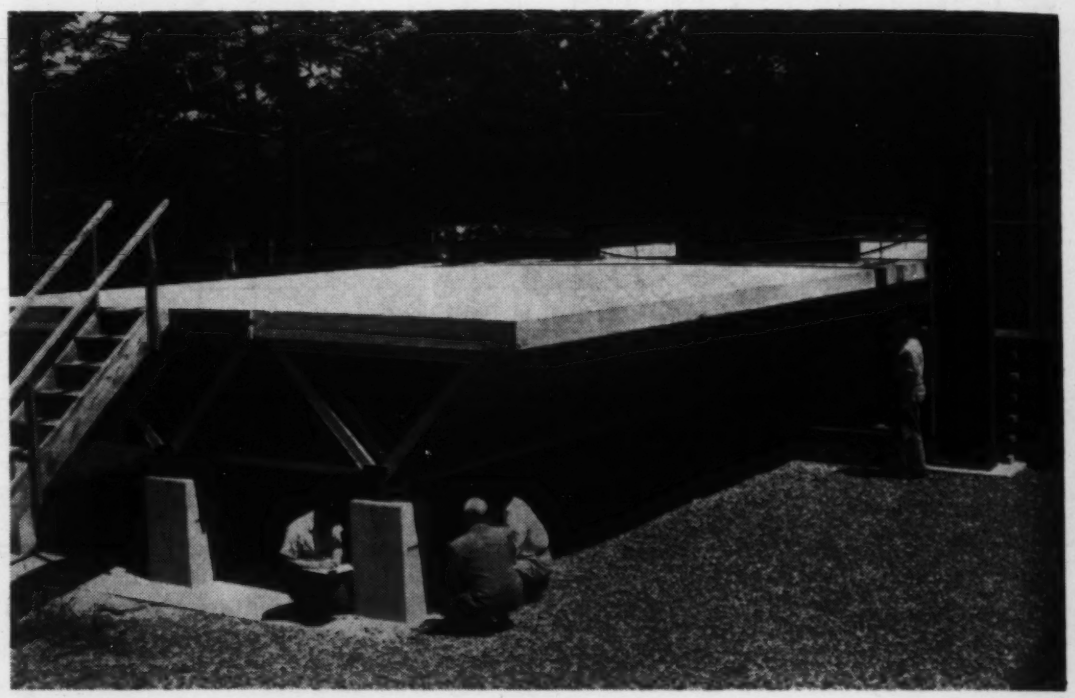
MATERIALS AT WORK

Bridge—cont'd from p 12

the aluminum bridge are: 1) low initial cost, resulting from high strength-weight ratio, ease of fabrication and the ability to prefabricate most of the bridge; and 2) low maintenance cost, resulting from the elimination of painting and other protective maintenance.

To test the bridge, special pulsating jacks were used to "shake" the section for more than a million cycles (equal to over 100 years of normal use). In addition, test loads of up to 53 tons (175% of the design load limit) were placed on the bridge without any indication of failure or excess fatigue.

The test, conducted at Lehigh University, was sponsored by Fairchild; the Bureau of Public Roads (U.S. Dept. of Commerce); Aluminum Co. of America; Kaiser Aluminum and Chemical Sales, Inc.; Metals Div., Olin Mathieson Chemicals Corp.; and Reynolds Metals Co.



Test section *of aluminum bridge with concrete roadway in place.*

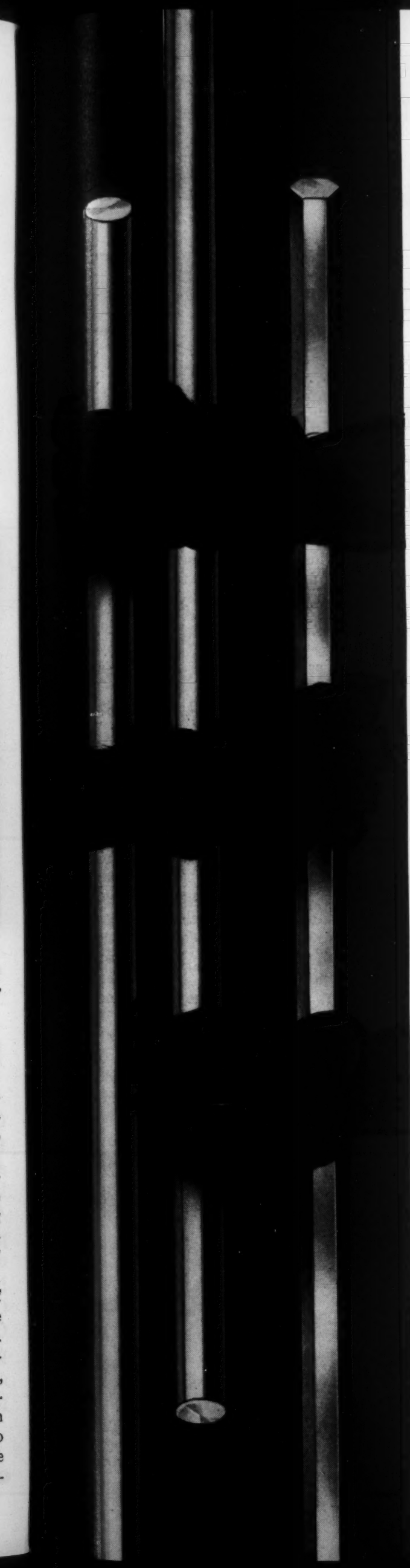
Ceramic Fixture for Silver Brazing

Although silver brazing in high temperature furnaces is an excellent method of joining precision metal assemblies at minimum cost, the technique presents a very serious problem to the process engineer: how to hold the assembly together through the preheat, high heat and cooling cycle so that tolerances can be met along with a sound bonding job.

According to Duramic Products, Inc., fired aluminum silicate fixtures allow silver brazing at temperatures up to 2000 F, with tolerances held to as close as ±0.0005 in. Because of its low thermal expansion (one-sixth that of steel) the aluminum silicate fixture does not warp and is said to hold parts in place accurately throughout the entire brazing cycle.

One of the ceramic fixtures presently used is shown in the photograph on p 192. The unit is used to silver braze at 1800 F a 4340 steel lever assembly carrying an alignment tolerance of ±0.0005 in. The fixture is designed to allow brazing of four assemblies at a time. Overall dimensions of the fixture are 7 by 1½ in. wide.

Clamping elements are made of ceramic because they must come into contact with the molten alloy. There are no threads in the ceramic; only a pin and nut arrangement, which loads the ceramic in compression. A quick-acting cam action is used to lock the assemblies into the ceramic and to exert positive pressure on the assembly through-



An announcement of interest to
manufacturers of steel parts

Improvements in today's STRESSPROOF® STEEL BARS WITH COPPER

1 **100,000 PSI YIELD STRENGTH** in all sizes . . . without heat treating.

2 **IMPROVED PHYSICAL PROPERTIES...** better fatigue life wearability, and resistance to atmospheric corrosion. Over-all quality is improved.

3 **IMPROVED MACHINABILITY...** STRESSPROOF with copper now machines faster and better than ever. It gives longer tool life, better finish, and more production from a day's run, according to shop production records.

4 **CLOSER TOLERANCES...** Tolerances for rounds have been tightened to meet the need for more precise parts as follows:

¼" to 1½"	Over 1½" to 2½"	Over 2½" to 3⅜"
+.000 −.004	+.000 −.005	+.000 −.006

5 **COMPARED WITH OTHER STEELS, STRESSPROOF COSTS EVEN LESS TODAY...** Also saves machining and heat treat costs, and you get a better quality part. It will pay you to take another look at this improved material.

Your STEEL SERVICE CENTER stocks contain today's STRESSPROOF. It has been produced and shipped over a several months' period.

JUST PUBLISHED! Use this coupon to request your copy of new bulletin, "Improvements in Today's STRESSPROOF Steel Bars."

La Salle STEEL COMPANY

1418 150th Street, Hammond, Indiana

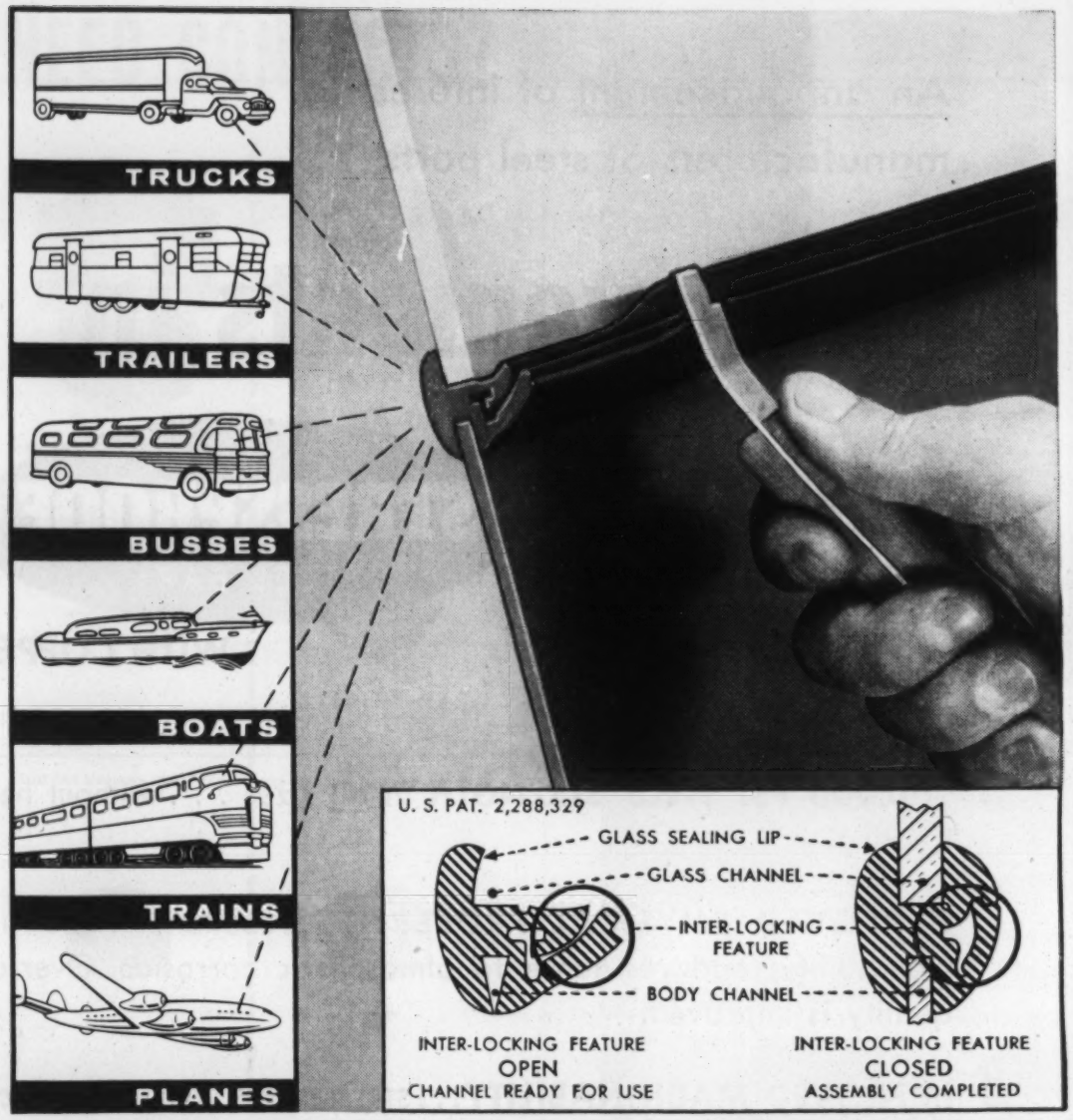
Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 535



Self-Locking Rubber Channel for Mounting Glass in Body Panels

Its *one-piece* design locks and seals in one operation. No extra locking-strip needed. It's the faster, simpler method for mounting glass in any type body panel—truck, trailer, bus, boat, train, plane, etc.

Extruded with inter-locking feature at direct right angle to body, the Continental Channel permits unhampered insertion of glass. Locking tongue is pressed into its matching groove which forces the lips against *both* the glass and body panel—a more positive seal with exceptional push-out pressure.

Compounded for maximum weather resistance and extra long life. Close durometer tolerances are held for uniformly tight seal against moisture and surest possible locking. These rubber channels can be positioned first on *either* glass or body panel. All details are shown in illustrated brochure gladly sent on request.

Ordered and re-ordered by the most prominent body builders, this Self-Locking Channel is another example of the creative thinking and ingenuity behind rubber parts by Continental. When you need rubber parts to do a specific job, call a rubber specialist *during the planning stage.* This often makes for economy as well as better end results. Call Continental —rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1985 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

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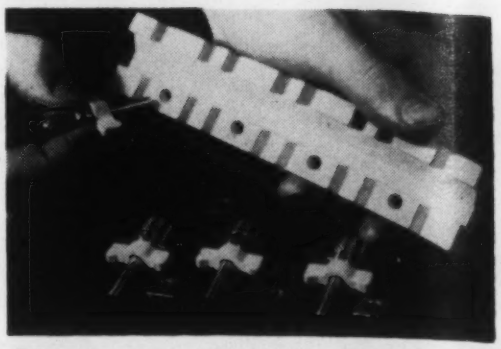


Aluminum silicate fixture *for silver brazing at 1800 F.*

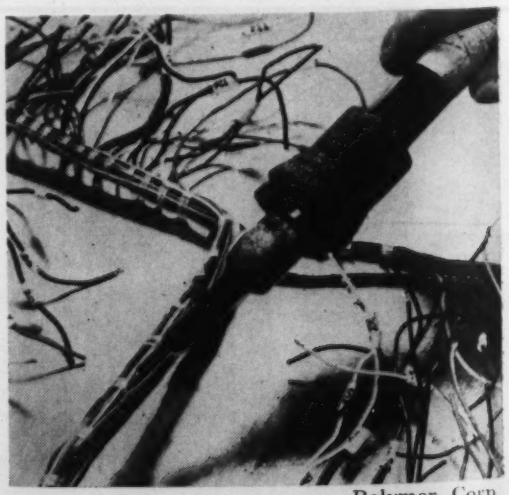
out the brazing cycle.

The ceramic fixture is precision ground after firing to allow for the ±0.0005-in. assembly tolerance.

Teflon Tubing, Molding Solve Design Problem

The use of Teflon spaghetti tubing and molded Teflon parts has solved three mechanical and electronic problems in the design of a miniaturized computer for an airborne navigation system:

1. The production of a compact, yet flexible, harness containing as many as 70 to 80 600-v wires. The use of Teflon (dielectric strength, 900-1250 v/mil; dielectric constant, 2.0-2.1 from 60 to 10^8 cycles; and volume resistivity, $>10^{10}$ megohm-cm), allows extremely thin-wall insulation (8-20 mils) and the entire cable is less than ¾ in. in dia. In addition, the Teflon spaghetti tubing has excellent flexibility, and this combination of flexibility and thin wall makes it possible to bend the



Polymer Corp.

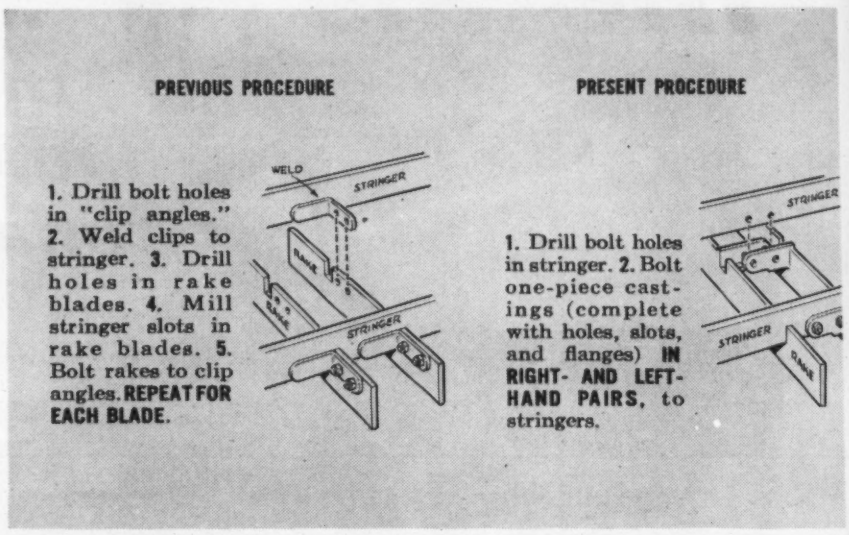
Teflon insulation *is not affected by hot soldering iron.*

How to cut costs, improve product design with stainless steel close-tolerance castings

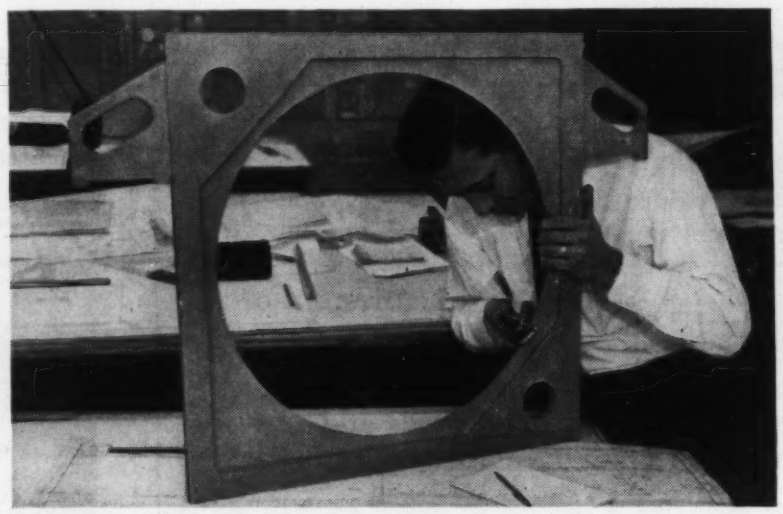
Cooper Alloy design collaboration with advanced casting techniques can simplify your fabrication, cut your costs. Here's how:

Casting of intricate parts: Jet engine afterburner component, cast for Pratt & Whitney Aircraft by Cooper Alloy, is a tangle of projections and cavities. Required, however, were the most precise dimensions to make for automatic precision machining. Shellcast® shell coring and CO_2 process cut down rejection and machining costs.

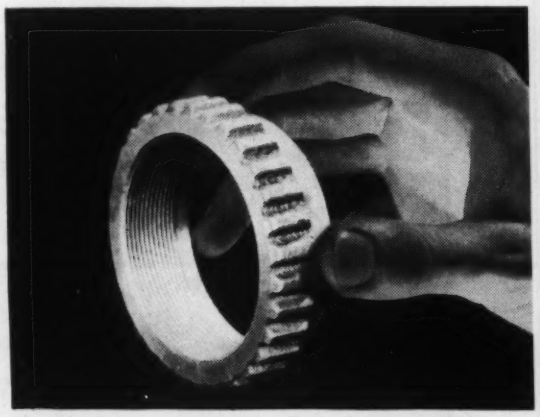
Strength and quality: Castings stronger than forgings! These Cooper Alloy nuclear service fittings possess high-temperature yield strengths 20% higher than minimum code specifications. Tough quality requirements have been met and bettered on a regular repetitive quality basis.


PREVIOUS PROCEDURE
1. Drill bolt holes in "clip angles." 2. Weld clips to stringer. 3. Drill holes in rake blades. 4. Mill stringer slots in rake blades. 5. Bolt rakes to clip angles. REPEAT FOR EACH BLADE.
WELD
STRINGER
RAKE
STRINGER
PRESENT PROCEDURE
1. Drill bolt holes in stringer. 2. Bolt one-piece castings (complete with holes, slots, and flanges) IN RIGHT- AND LEFT-HAND PAIRS, to stringers.
STRINGER
STRINGER
RAKE

Part redesigned, simplified, assembly costs lowered. Classifier rake blade, Shellcast® by Cooper Alloy for Dorr-Oliver Inc., was originally made by welding cast and machined elements. Close-tolerance, smooth-surface shell castings made possible design change to one-piece cast unit, eliminating welding and much of the assembly costs.



Casting of thin-walled close-dimensioned parts. Tennessee Eastman filter frame plate previously required a good deal of careful milling on thin inner web. Combined use of shell core in a sand mold held tolerances, eliminated milling operation.



Product improvement: Gear lugs on adjusting ring for Manning, Maxwell & Moore pressure safety relief valve, formerly sand cast, are now being produced directly by Shellcast® process. Dimensional accuracy possible with shell castings permitted redesign of part to give more lugs, finer adjustability in use.

If you haven't looked over your fabrication and assembly costs lately, check the unusual cost-saving techniques listed in the capsule stories shown above. They are typical of Cooper Alloy advanced casting know-how. Many parts and assemblies that you probably haven't even considered as makable by castings, can be now by Cooper Alloy, specialists for over 35 years in casting *only* stainless steel.

Want more information? To learn more of how Cooper Alloy know-how can help cut *your* manufacturing costs, write for our free 16-page booklet, "Cooper Alloy—Pioneering in Stainless Steel." Also available, information on the other problem-solving Cooper Alloy products listed below.

COOPER ALLOY

Corporation • Hillside, New Jersey

SPECIALISTS *in Stainless Steel valves, fittings, castings; Plastic pumps, pipe, valves, fittings*

For more information, turn to Reader Service card, circle No. 450

metals ... ...to match man's imagination

Conventional metals can no longer provide the solution to design, construction and performance problems confronting the aviation and missile industries, among others. That's why metallurgists and technicians in Wallingford's all-new laboratories are constantly researching metals that will keep pace with the imaginativeness of designers and engineers.

Now, Wallingford can deliver, *from available stock,* many of these stainless steels and super metals with special characteristics and properties:

SUPER ALLOYS

A 286 AM 350 AM 355
M 252 N 155 R 235 V 36
Rene 41 Zirconium (vacuum annealed)
Haynes 25 Hastelloy B, C and X
19-9 DL

FACILITIES FOR WIDTHS UP TO 27" — THICKNESSES DOWN TO .001 — EXTREMELY CLOSE TOLERANCES MAINTAINED.

Whatever your requirements, Wallingford can help you. Write to The Wallingford Steel Co., Wallingford, Conn.

THE WALLINGFORD STEEL CO.

Progress in Metals for over 36 Years

WALLINGFORD, CONN., U.S.A.

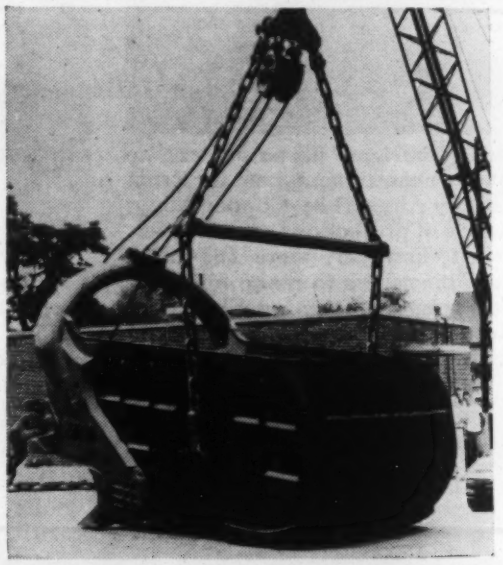
COLD ROLLED STRIP: Super Metals, Stainless, Alloy
WELDED TUBES AND PIPE: Super Metals, Stainless, Alloy

For more information, turn to Reader Service card, circle No. 530

completed harness into and around the corners of the various sections used in the computer without affecting its electrical properties.

2. The tendency of previously used vinyl insulation to peel and burn when touched by a hot soldering iron. The Teflon wire covering neither burns nor peels under the heat of a soldering iron. The heat resistance of the Teflon spaghetti tubing is also used to good advantage whenever it is necessary to repair or replace any wire in the harness. A fabric with a melting point less than 500 F is used for the lacing and when the cable has to be opened, the fabric is merely burned off with the hot soldering iron; the Teflon tubing is not affected.

3. Mounting two toroids back-to-back on opposite sides of a mounting base. Ambient temperatures as high as 250 F and the presence of six leads coming from each toroid complicated the problem. A phenolic



Largest bucket—Manganese steel and alloy 12M castings and T-1 alloy steel plate are combined in what is claimed to be the largest dragline bucket ever made. Weighing 69,000 lb and having a capacity of 35½ cu yd (over 180,000 lb), the bucket measures 11 ft, 2 in. wide, 13 ft, 5 in. high and 18 ft, 9 in. long.

According to Electric Steel Foundry, Co., manufacturers of the bucket, the drag chain and bucket teeth are integrally cast. Each chain link weighs 90 lb; each tooth, 177 lb. The bucket requires hoist cable made of 2¾-in. wire rope and drag cable made of 3⅛-in. wire rope.

Colonial

can solve *your* SILICONE RUBBER parts problems, too . . .

Molded from various formulations of silicone rubber, these industrial rubber parts were compounded to meet the design engineer's specifications precisely. They are components of various products from home appliances to super-sonic planes, and are typical of the work we do here at Colonial Rubber Company. Check us today on your molded rubber parts requirements. We regularly compound silicone rubber parts for:

Heat Resistance	**up to 600 deg. F.**
Cold Resistance	**down to —100 deg. F.**
Chemical Resistance	**over 600 deg. F. range**
Dielectric Properties	**as required**
Strength Combinations	**shear, tensile, elongation**

Whether you need compound development, parts production or both, contact us. We have a long background of industrial rubber experience, plus complete laboratory and production plant facilities to meet your "toughest" rubber parts requirements quickly, dependably and **economically.**

Write for our brochure . . .

Contains complete, illustrated details on Colonial's **custom** rubber compounding and molding service. No obligation.

1533A

COLONIAL RUBBER CO.
RAVENNA, OHIO

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can you use
ultra-thin **metal strip**

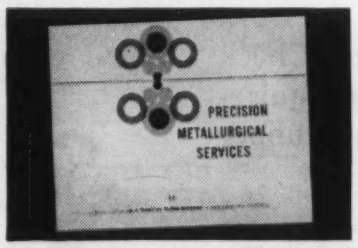
that is only 1/15 as thick

as a nylon stocking thread ?

Hamilton's Precision Metals Division is now producing metal strip and foil in practically any alloy in thicknesses ranging from .010″ to .0001″. (The thickness of a 15 denier nylon thread is approximately .0017″.)

For designers and engineers faced with problems of miniaturization and subminiaturization, precision material like this is solving important problems today, and opening the way to future developments. Precision Metals Division strip and foil are produced to exact mechanical and physical specifications, and they are available in any quantity for development or production. Special alloys can also be developed to customer specifications and furnished in whatever form is required.

The modern, specialized equipment of this completely integrated metals processing plant is described in an illustrated facilities booklet. Write for your copy today to Dept. DE-11.



Hamilton Watch Company

Precision Metals Division / Lancaster, Pennsylvania

Creator of the world's first electric watch

For more information, turn to Reader Service card, circle No. 481

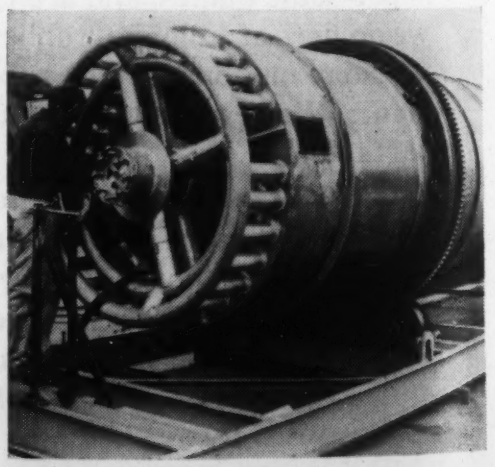
post was first tried, and although it withstood the heat, the applied stress caused cracking. Nylon was also tried, but proved inadequate not only in heat resistance, but also because it has no "give" to take up variations in the assembly.

A molded T-shaped Teflon cylinder with a wire pin passing through solved the problem. The cylindrical terminal is pressed into a hole of slightly smaller diameter in the mounting base. The part extending through the mounting base returns to its original size and forms a securely anchored grommet. The Teflon part is not affected by the heat and has proved flexible enough to conform to required tolerances.

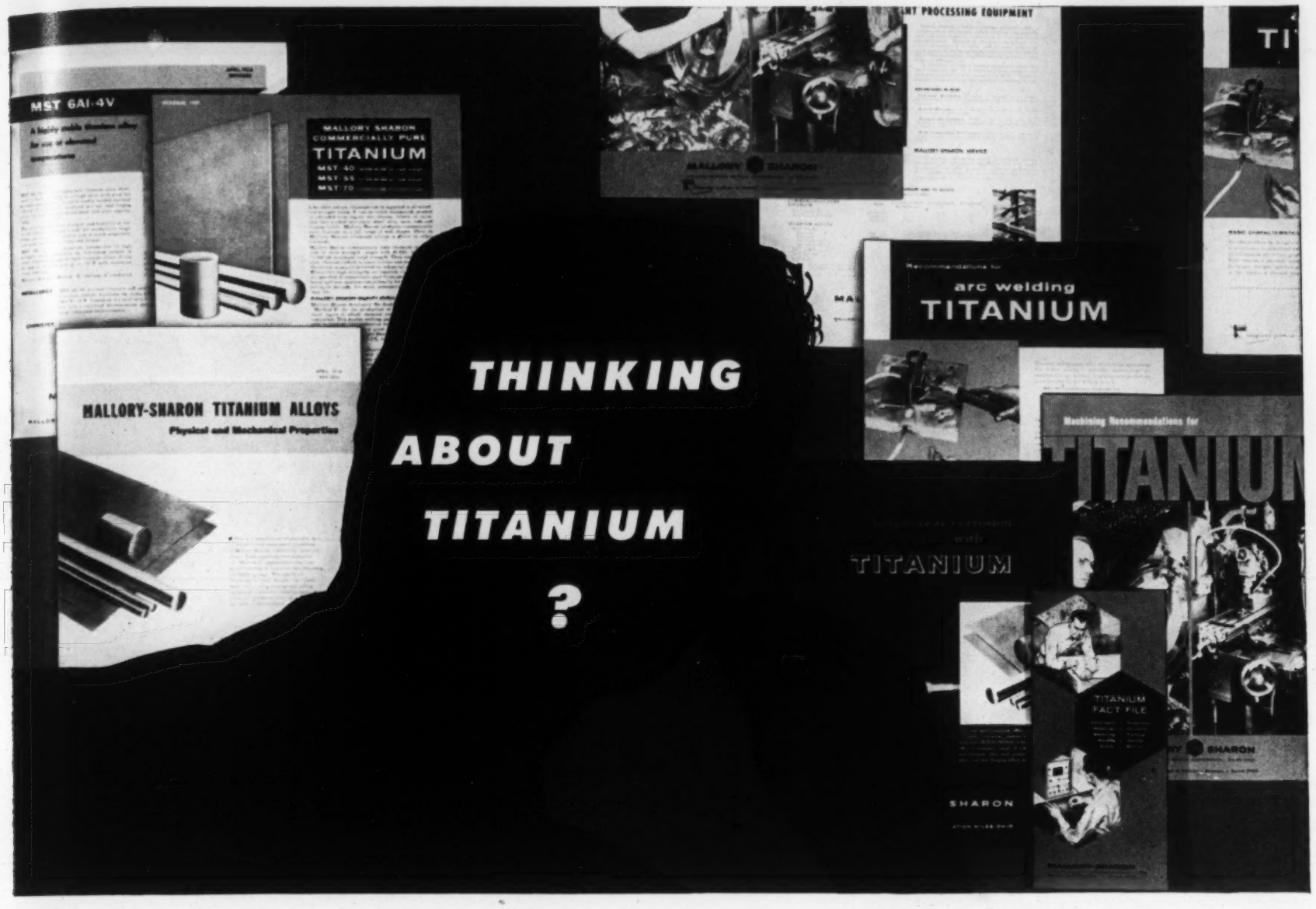
First All-Welded Aluminum Tube Dryer

The steam tube dryer shown in the accompanying photo is said to be the first all-welded aluminum dryer ever made. According to Standard Steel Corp., the unique construction was used to achieve cost savings as well as greater strength and longer life.

With the exception of tires, driving gears, trunnion roll assemblies and bed frame, the dryer is constructed entirely of aluminum, with stainless steel pads separating the dissimilar metals to prevent electrolytic corrosion. Steam is supplied to the dryers through a floating-type rotary joint made of stainless steel and aluminum designed specifically for this application. The unit is being used in W. R. Grace & Co.'s high density polyethylene plant.



***Welded aluminum** reduces cost and extends life of steam dryer.*

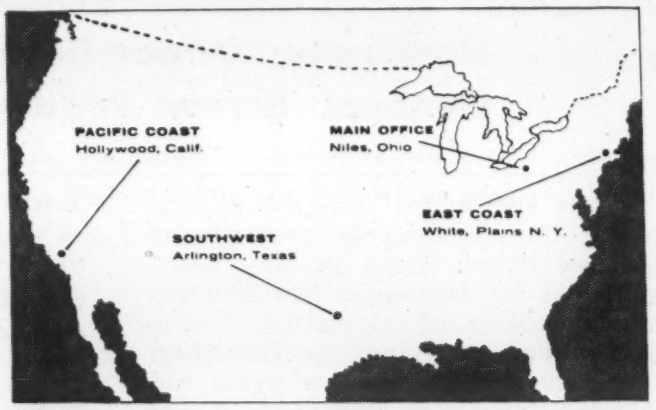


Help yourself to this helpful data

Mallory-Sharon, as a pioneer in titanium technology and largest integrated producer of special metals, offers you a wealth of technical assistance . . . both in print and in person.

Technical bulletins on titanium's properties and advantages are available through Mallory-Sharon headquarters or sales offices. They're yours for the asking. Use coupon below.

On special problems or applications, our experienced Service Engineering group is ready to work with you. To make use of this application service, just phone or write your nearest Mallory-Sharon sales office.



Mallory-Sharon Sales Offices *are strategically located throughout the U.S.A. We'll gladly send you the name of our representative in office nearest you.*

MALLORY MS **SHARON**

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

- ☐ Arc Welding Titanium
- ☐ Machining Recommendations for Titanium
- ☐ Titanium Alloys: Physical and mechanical properties
- ☐ MST 6Al-4V Titanium Alloy
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Mallory-Sharon Metals Corporation
Niles, Ohio

Please send me the technical bulletins on titanium checked at left.

Name_____

Title_____

Company_____

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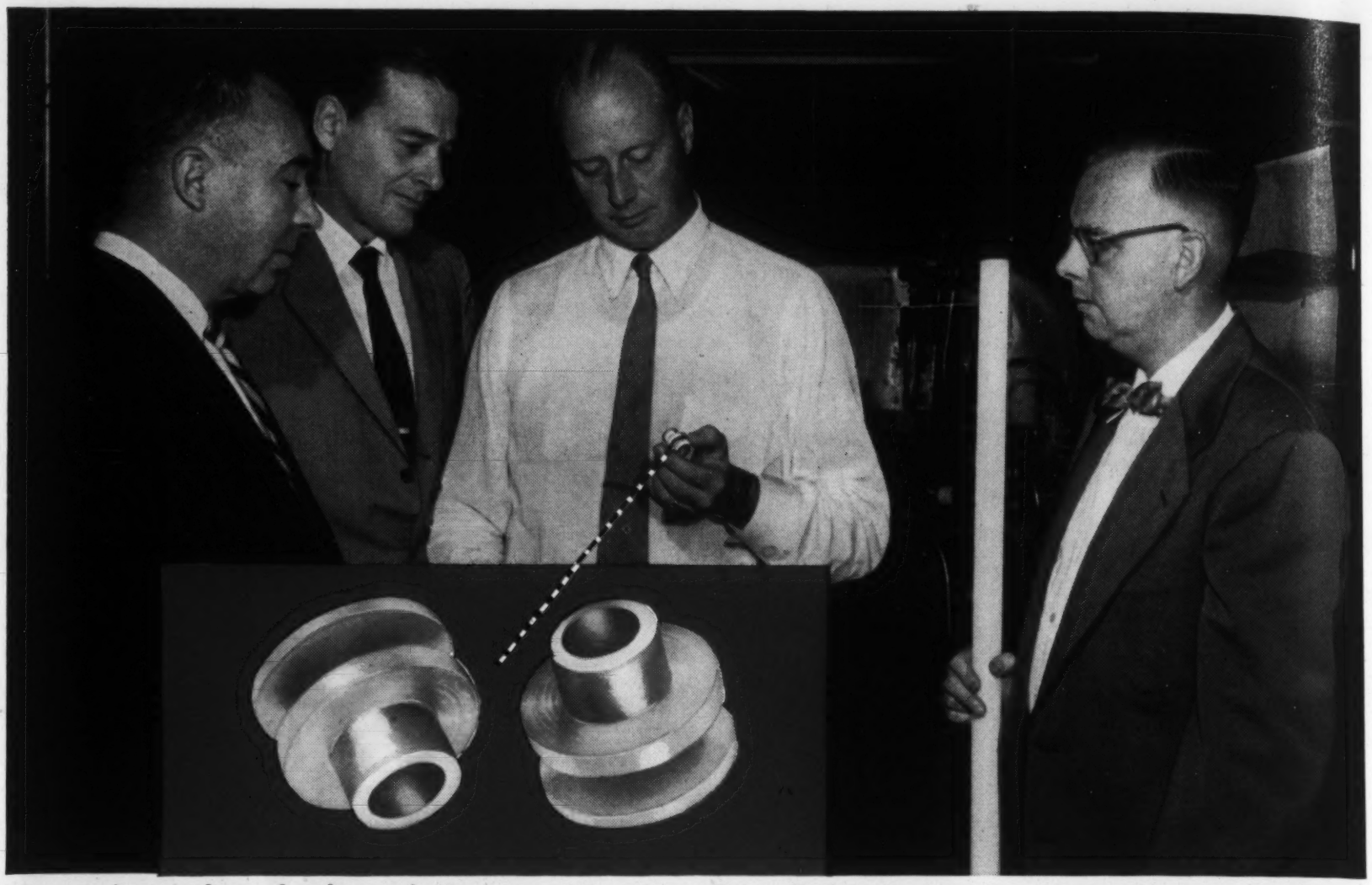
City & State_____

For more information, turn to Reader Service card, circle No. 492



More units per foot of nylon rod—that's one of the many benefits Charles DeMartin (third from left), President of General Screw Products, got by switching to the new, longer Danco Rod made of Spencer Nylon. Finished nylon part is used in lens carriage assembly of a Haloid Xerox® photocopying machine.

Leading user of nylon rod reports:

150% Less Handling...5% Less Bar-End Loss

How new 10-foot Danco Rods made of Spencer Nylon help General Screw Products turn out more parts at less cost:

"Bigger and better" may be general terms, but they apply perfectly to the new 10-foot nylon rod now being marketed by Danielson Manufacturing Company of Danielson, Conn. Using Spencer Nylon, the Danielson Company has developed a nylon rod that is 2½ times as long as the 4-foot rod other companies produce!

One of the first to cash in on the many advantages offered by the new Danco Rod was General Screw Products of Rochester, N. Y. The 10-foot rod of Spencer Nylon pays off for them three ways:

Since they don't change lengths so often now when machining parts, there is **(1)** less machine down-time, **(2)** less handling, and **(3)** more unit production per man-hour of work. But that's not all!

With more usable work surface per rod, there is less bar-end loss. General Screw Products reports that the Danco Rods of Spencer Nylon give them a saving of one foot of material in every twenty feet used! Also, the rods of Spencer Nylon have proved to have greater tenacity than the rods previously used. The rods have a finish "equal to or better than" the rods formerly used, which General Screw Products had considered to be the best available for their machine operation—until the Danco Rods of Spencer Nylon were developed!

You, too may discover that the special properties of Spencer Nylon make it the ideal plastic for your nylon needs. For complete information, write: Spencer Nylon, Spencer Chemical Company, 600 Dwight Bldg., Kansas City 5, Missouri.

YOU ARE CORDIALLY INVITED TO
Booth 219
NATIONAL PLASTICS EXPOSITION
November 17-21

SPENCER NYLON

SPENCER CHEMICAL COMPANY

SPENCER®

GENERAL OFFICES: DWIGHT BUILDING, KANSAS CITY 5, MISSOURI

For more information, turn to Reader Service card, circle No. 534

PRICES AND SUPPLY

...AT A GLANCE

PRODUCTION OF HIGH PURITY TANTALUM METAL is now underway at National Research Corp.'s plant in Cambridge, Mass. According to the company, the metal is commercially available in a purity hitherto unattainable. Annual production is 30,000 lb; however, the company expects to expand its production in the near future.

PRICES OF EPOXY RESINS HAVE BEEN REDUCED by Shell Chemical Corp. and Ciba Co., Inc. Shell's new prices are: 62¢ per lb for liquid epoxy, down from 77¢, and 53½¢ per lb for solid epoxy, down from 59½¢. Ciba cut its liquid resin price an average of 12-15¢ per lb and its solid resin 5¢ per lb.

COPPER PRODUCTION HAS BEEN INCREASED by about 3800 tons per month by Kennecott Copper Corp., in spite of the fact that producers' stocks of copper are still quite high. According to the company, the increase resulted from "good business" and "strong demand in Europe." Kennecott had curtailed production several times during the past year. The company's new rate of production is 24,900 tons per month.

PRICES OF MYLAR POLYESTER FILM HAVE BEEN REDUCED by Du Pont for the fifth time since the start of commercial production four years ago. Type A was reduced 20¢ per lb; Type C, 10¢ per lb; and Type K-24, 10¢ per lb. The reductions bring the overall price down to the range of $1.80-3.90 per lb.

PRODUCTION OF PRIMARY ALUMINUM is slated for a 50,000-ton-per-year increase when Harvey Aluminum's new reduction plant reaches capacity production within the next few weeks. According to Harvey, the new plant represents the first independent aluminum reduction plant in the United States.

PRICES OF TIN DROPPED DRASTICALLY after the International Tin Council suspended supporting operations several weeks ago. In London, the price plummeted 11¢ per lb and in New York, nearly 9¢ per lb. The Council did not disclose why props were withdrawn but trade sources indicated that the agency had run out of cash because of substantial offerings of Russian tin in free world markets.

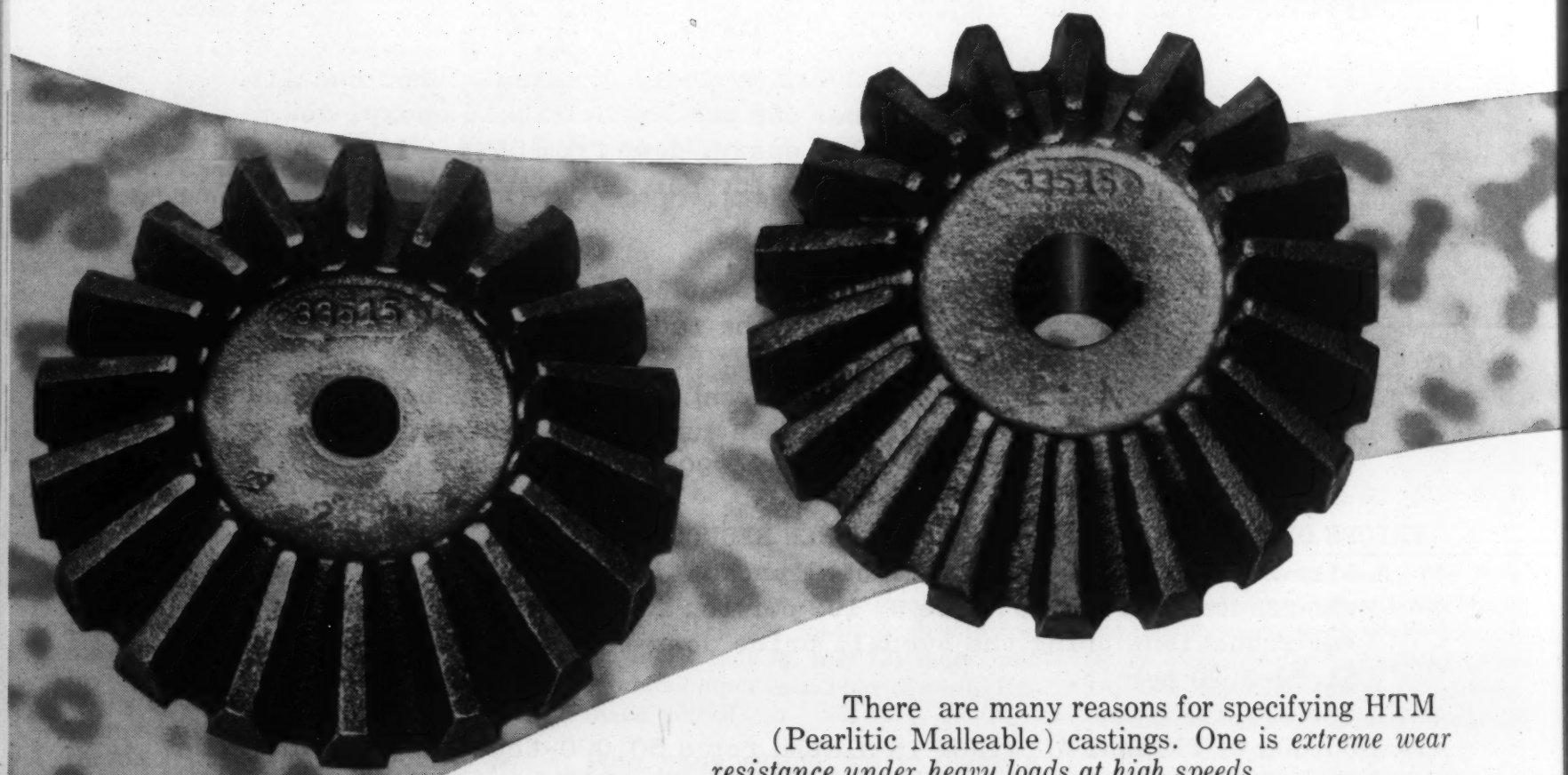
See Other News on p 201

is your problem

wear resistance?

NATIONAL HTM CASTINGS

are the answer



There are many reasons for specifying HTM (Pearlitic Malleable) castings. One is *extreme wear resistance under heavy loads at high speeds.*

But there are many other reasons, too. For example, close as-cast tolerances can often eliminate machining operations such as on the gear teeth shown above. In this case, it was only necessary to drill and machine the key slot.

Other worthwhile advantages of HTM are high ultimate strength . . . excellent non-seizing bearing qualities that can eliminate costly bushings . . . air or liquid quenching . . . ability to be smooth-finished.

So when you're looking over the materials field, don't overlook the advantages of HTM castings. For HTM metal can be cast by either the shell mold, CO_2, or green sand method. This means production costs tumble . . . performance and saleability of your product go up.

AA-6928

IMPORTANT PHYSICAL PROPERTIES	
Brinell	163 to 302*
Yield, psi	48,000 to 85,00
Ultimate, psi	70,000 to 110,0
Elongation, %	7 to 2*

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY

Established 1868 *Cleveland 6, Ohio*

The nation's largest independent producer of malleable and pearlitic malleable

Other News . . .

Prices of zirconium sponge have been cut by Mallory-Sharon Metals Corp. New prices are $6 per lb for quantities over 500 lb; $6.50 per lb for quantities between 500 and 100 lb; and $7 per lb for less than 100 lb. According to Mallory, the cut was made possible as a result of the successful operation of the company's sodium reduction process.

Processing of tinplate and steel plate for the manufacture of metal cans is now being performed in the "world's first plant devoted exclusively to this operation." The plant, located at Hammond, Ind. and operated by American Can Co.'s Canco Div., has the capacity to produce up to 1.2 billion pounds of plate per year. Purpose of the new plant is "to produce containers of even better quality at the lowest possible cost."

Consumption of reinforced plastics in 1958 should end up about 10% higher than in 1957, according to A. W. Severhagan, general chairman of the Reinforced Plastics Div. of the Society of the Plastics Industry, Inc. The prediction was based on two facts: 1) consumption of polyester resins is thus far 13% higher than in 1957 (polyesters comprise about 92% of all resin used in reinforced plastics), and 2) production of glass for plastics reinforcement is running at full capacity.

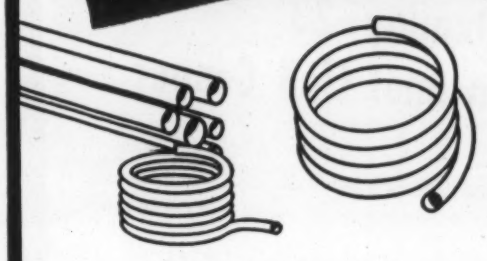
A 20% reduction in lead production was recently made by St. Joseph Lead Co. The company says it is producing more metal than it can sell and "we're terribly hurt by imports." The cut followed the defeat in Congress of the minerals subsidy bill.

Prices of electroplating salts were recently reduced by Du Pont. Copper cyanide and potassium cyanide have been cut 2½¢ per lb to 60.9¢ and 42.5¢ per lb, respectively. Two other salts, Coppralyte and a sodium-copper cyanide double salt, were reduced 1¢ and 1.1¢ per lb, respectively. For all products except potassium cyanide, the price cut was the second this year.

Polypropylene production capacity will be increased from 15 to 45 million pounds per year at Montecatini's plant in Ferrara, Italy. Increased demand for the new plastic has stimulated Montecatini to complete its expansion sometime before the end of the year.

Series 2

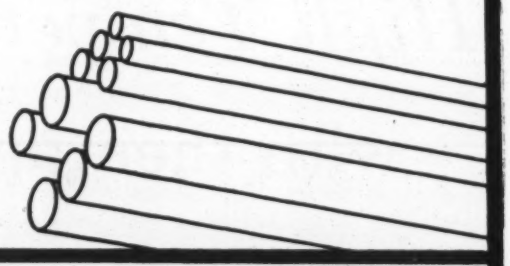
PLUS ITEMS
from your
Whitehead Metals
"Supermarkets"



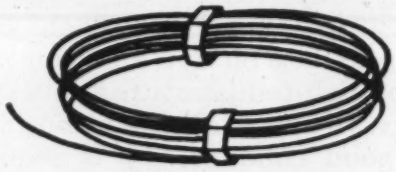
PLASTIC PIPE
A full line of flexible and rigid plastic pipe and tubing in all commercial resins, in sizes from ⅛″ to 4″ OD. Fittings, cements and valves available from stock. Write for detailed literature.

NON-SKID ALUMINUM TREAD PLATE
Providing amazing gripping power (either oily or dry) this lightweight, corrosion resistant Alcoa product has a tough abrasive (fused aluminum oxide) rolled right into an aluminum base plate for longer wear. Available in four thicknesses —0.125″, 0.188″, 0.250″ and 0.375″ Write for descriptive booklet.

SHAFTING
Top quality shafting made of Monel, Tobin Bronze or Tempaloy. Originally developed for boats and other marine use, these shafts have gained wide industrial use in pumps and other machinery operating in corrosive atmospheres. Literature available.



WELDING FITTINGS
Stainless Steel forged welding fittings are stocked in I.P.S. sizes from ½″ to 12″ for Schedule 5S, 10S, 40S and 80S Pipe. All conventional shapes are on hand. Welding fittings are also stocked in Aluminum, Monel, Nickel and Inconel. Literature available.



DISSIMILAR METALS WELDING WIRE
A new item introduced at the 1958 Welding Show, Inco-Weld "A" Wire is a single product for inert gas welding of most combinations of dissimilar alloys. Technical Service and complete literature on request.

These "Plus Items" and many more are available in addition to a wide selection of corrosion-resistant sheet, rod and tube.

All told, there are more than 20,000 items distributed and serviced by Whitehead. All are available, off-the-shelf, from the nine Whitehead Metal "Supermarkets." All are the products of such leading producers as Alcoa, Anaconda, Inco & Crucible Steel to name just a few.

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( ) 1100°F	2. Kulgrid® 28
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*Trade-mark

Can you match these Sylvania *High Temperature Wires* with their applications?

GET THEM ALL RIGHT? Then you're right up to date on Sylvania composite wires for high-temperature applications in corrosive and oxidizing atmospheres where good conductivity is required. (You can check your answers with the chart below.)

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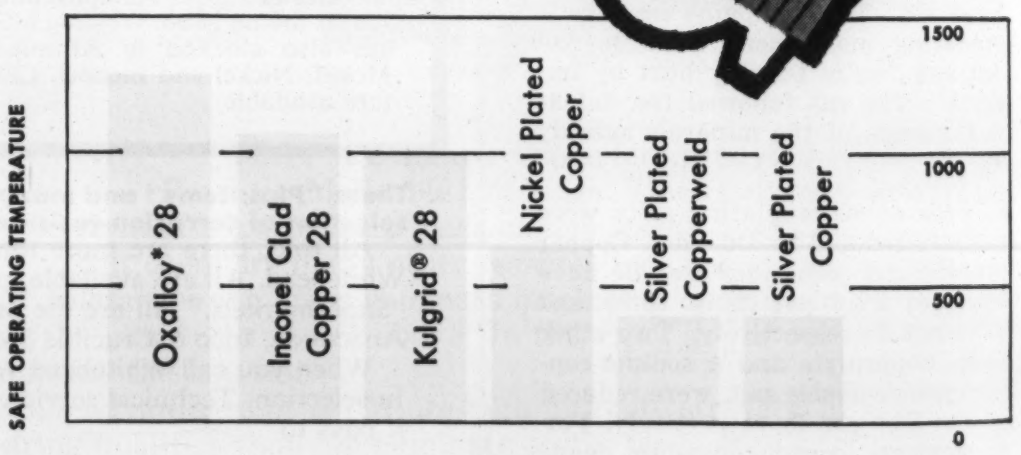
If you're not yet completely familiar with Sylvania High Temperature Wires, write for your "Product Bulletin." As a major supplier of both clad and plated wires, Sylvania is in a unique position to offer objective recommendations on the best wire for your application. Address your inquiry to

SYLVANIA ELECTRIC PRODUCTS INC.,
Parts Division, Warren, Penna.



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News OF INDUSTRY

Better Materials, Processes Aim of New Labs

Improvement of existing materials and processes and development of new and better materials and processes have always been among the major aims of research. Within the past few years the number of new research and development laboratories has increased substantially. The following brief reports cover some of the most recent work being done in the field of engineering materials and processes.

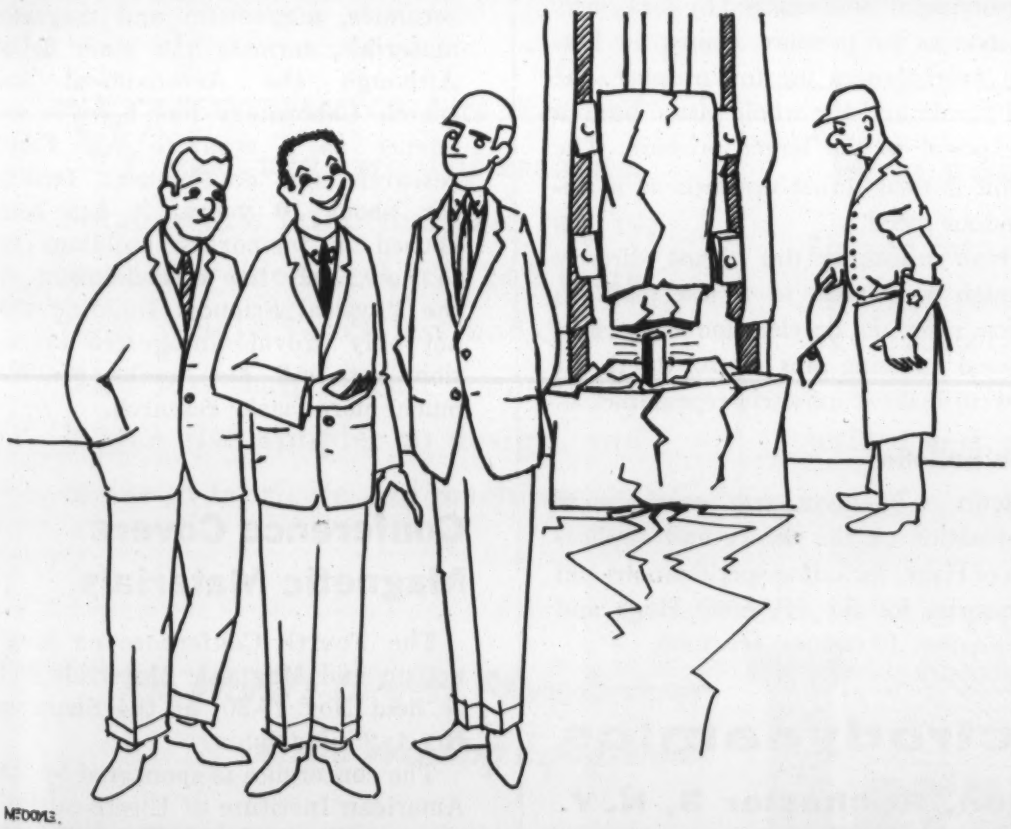
▸ Ceramic research and development has been given a substantial boost by Westinghouse's new integrated high temperature induction melting, sintering and pressing laboratory. The laboratory will be used to help predict product designers' requirements in ceramic materials. It is currently used for ceramic development projects on nuclear fuels, infrared transmission glasses, thermoelectric generator materials, and preparation of high temperature oxide and intermetallic compounds.

▸ An applied research laboratory, designed for the development of advanced methods of foundry technology, has been put in operation by General Electric Co. Purpose of this laboratory is to provide the "vital link between pure research from which is developed new materials and processes, and the actual foundry use of such materials and methods." Projects currently underway include development of: improved methods of eliminating gaseous impurities in molten cast metals; improved methods of vacuum melting and processing cast alloys to reduce impurities and improve cast properties; improved precision casting methods; and methods for reducing the quantity of metal needed for risers in castings.

▸ A plastics research and development laboratory, designed to operate in conjunction with already existing paint research facilities, has been established by Glidden Co. Purpose of the new laboratory is to utilize the "increasing similarities of paint and plastics to improve both products." The laboratory is equipped to carry out development programs from the synthesizing stage to the compounding of materials for various molding, laminating, casting and coating operations. In addition, the laboratory is set up for reinforced plastics molding by preform, mat or premix methods. Primary efforts will be devoted to research and development work on polyester resins for molding, casting and coating; rigid polyurethane foams for insulating and structural applications; and butoxy resins for coating and casting.

▸ A new structural laboratory, which is itself a giant testing machine capable of exerting forces greater than 10 million lb, is said

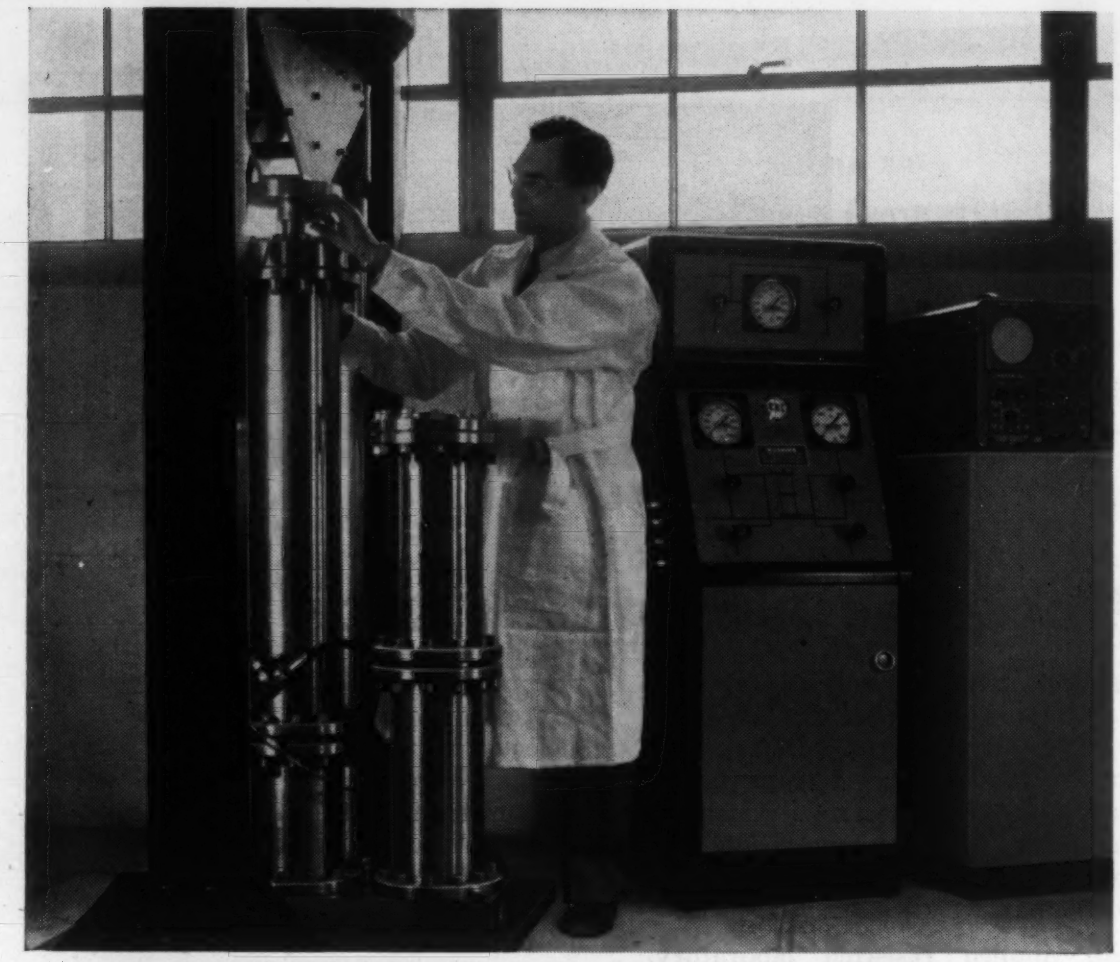
THE HARD SELL



"Of course, gentlemen, this new alloy still has some minor drawbacks."

PLASTICS SHOW—See pp 19-27 for complete details on registration, technical program and exhibitors at the 8th National Plastics Exposition and Annual Conference, Nov 17-21, in Chicago.

For more information, circle No. 413



Hyge shock tester takes about 60 seconds to complete acceleration-shock test with up to 40,000 lbf. thrust. Hughes Products Memoscope® oscilloscope retains wave pattern as long as you like for careful study and comparison with master pattern.

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With Hyge you can accelerate a specimen to several hundred g's in just milliseconds with exact reproduction of preset half-sine, square, and sawtooth patterns.

How it works

Hyge is a piston in a cylinder which is divided by an orifice plate. Using nitrogen, you build up a small pressure against the top of the piston, sealing it to the orifice plate. You can then build up a very large pressure against the bottom of the piston, since you are working against only the small area exposed by the orifice. As soon as the pressure against the bottom overbalances the top pressure, the seal breaks and the whole piston bottom is exposed to the larger pressure. The piston is then thrust upwards at a tremendous speed.

Hyge transmits this thrust directly through a column to a test platform which rides on deceleration rails. Preselected metering pins control the thrust pattern, make it infinitely repeatable.

Free bulletin

Bulletin 4-70 gives you much more information on the theory and application of Hyge, including specifications and accessories for the HY-6000 Hyge and the smaller, 10,000 lbf. Hy-3000.

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Rochester Division, Rochester 3, N. Y.

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News OF INDUSTRY

to be capable of testing any concrete structural element—from a short girder to a full-size floor slab or roof shell. The laboratory, built by the Portland Cement Assn., will be concerned with: improving connections between precast concrete elements; developing methods of achieving continuity between prestressed concrete units; improving design of various types of concrete floor systems; and developing additional engineering information on newer types of concrete shell roofs.

▸ The development of new silicone products will be carried out in a new laboratory built by the Silicone Products Dept., General Electric Co. According to GE, the new laboratory is part of a multi-million dollar expansion program aimed at the development of new and improved silicone materials and products. Work in the new laboratory will concentrate on silicone gums and rubber compounds, fluids, resins and emulsions.

▸ The recently completed Physical Sciences Building at Wright Air Development Center's Aeronautical Research Laboratory is designed to perform basic research in chemistry, engineering physics, metallurgy, mechanics, fluid dynamics, ceramics, magnetism and magnetic materials, cermets and other fields. Although the Aeronautical Research Laboratory has been in existence as a separate Air Force research and development facility for about 10 years, it has been housed in temporary buildings up to now, and the establishment of the Physical Sciences Building will not only provide integrated operation but will also make possible much more basic research.

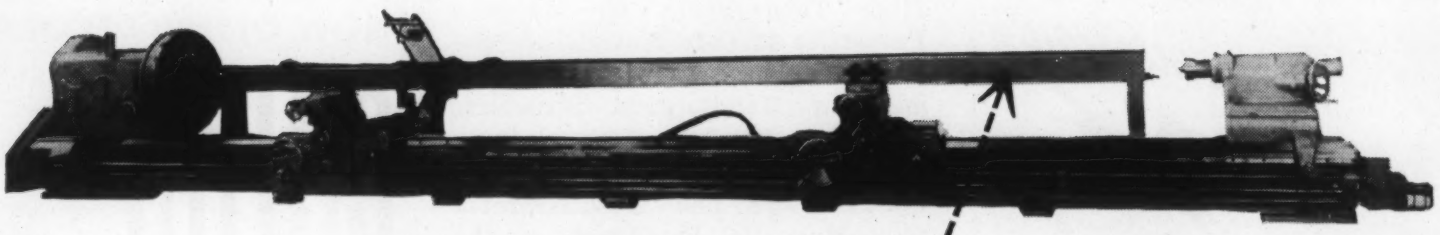
Conference Covers Magnetic Materials

The Fourth Conference on Magnetism and Magnetic Materials will be held Nov 17-20, at the Sheraton Hotel, Philadelphia.

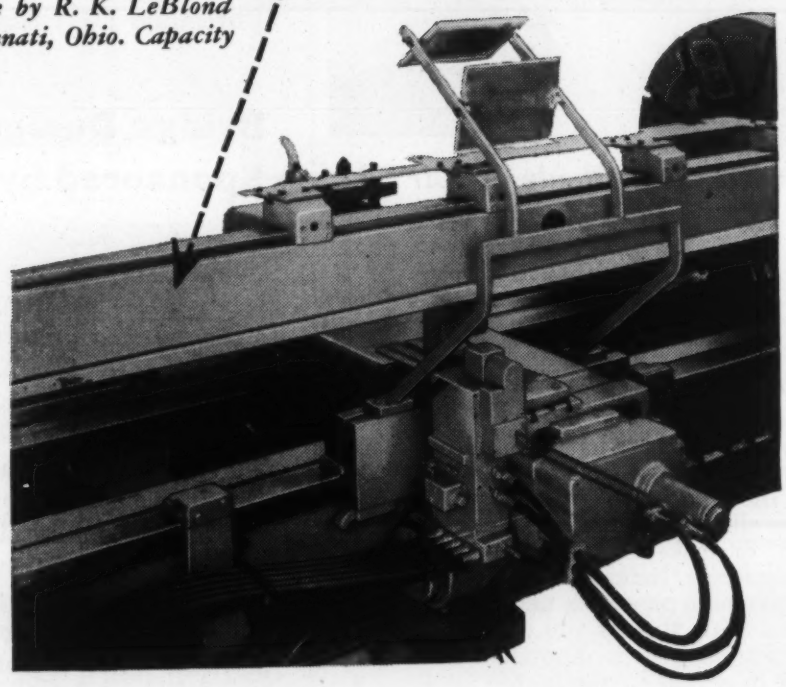
The conference is sponsored by the American Institute of Electrical Engineers in cooperation with the American Physical Society, the Institute of Radio Engineers, the Met-

Weldynamics

ARC WELDING AT WORK CUTTING COSTS



Duplicating lathe made by R. K. LeBlond Machine Tool Co., Cincinnati, Ohio. Capacity 37' between centers.



Planning for profit demands designing for lower cost

WELDYNAMICS lets you use steel and save. For example, because this lathe template rail is made of welded steel, it is 24% more rigid, weighs 54.6% less, and costs a third less than its cast counterpart. It was also simpler to design, and easier to fabricate and machine.

How you can use Weldynamics

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News OF INDUSTRY

allurgical Society of AIME and the Office of Naval Research.

Some of the papers scheduled for presentation include: "Low Temperature Magnetic Properties of Nickel-Iron Ferrite," "Effects of High Temperature on Magnetic Properties of Core Materials," "Superparamagnetism," "The Development of Metallurgical Structures and Magnetic Properties in Iron–Silicon Alloys," "Brittleness in Iron-Cobalt Alloys" and "Low Temperature Magnetic Properties of the Chromium (III) Halides."

Bridge Design Contest Sponsored by U.S. Steel

A steel highway bridge design competition offering 15 awards totaling $44,000 to engineers and college engineering students is being sponsored by the American Bridge Div., U. S. Steel Corp.

Purpose of the competition is to stimulate the best use of steel in the design of bridges for the 41,000-mile system of interstate and defense highways to be built during the next 15 years.

According to the rules of the competition, each entrant must design an overpass structure made of steel which contains a two-lane highway running at right angles over a four-lane interstate highway on level ground.

Complete information may be obtained from American Bridge Div., U. S. Steel Corp., 525 William Penn Place, Pittsburgh 30, or from the American Institute of Steel Construction, 101 Park Ave., New York 17.

Information Center Replaces Titanium Lab

The Titanium Metallurgical Laboratory at Battelle Memorial Institute has been replaced by the Defense Metals Information Center. According to the Dept. of Defense, the move was made in order to broaden the agency's responsibilities to include research on beryllium, refractory metals, high strength alloys for high tempera-

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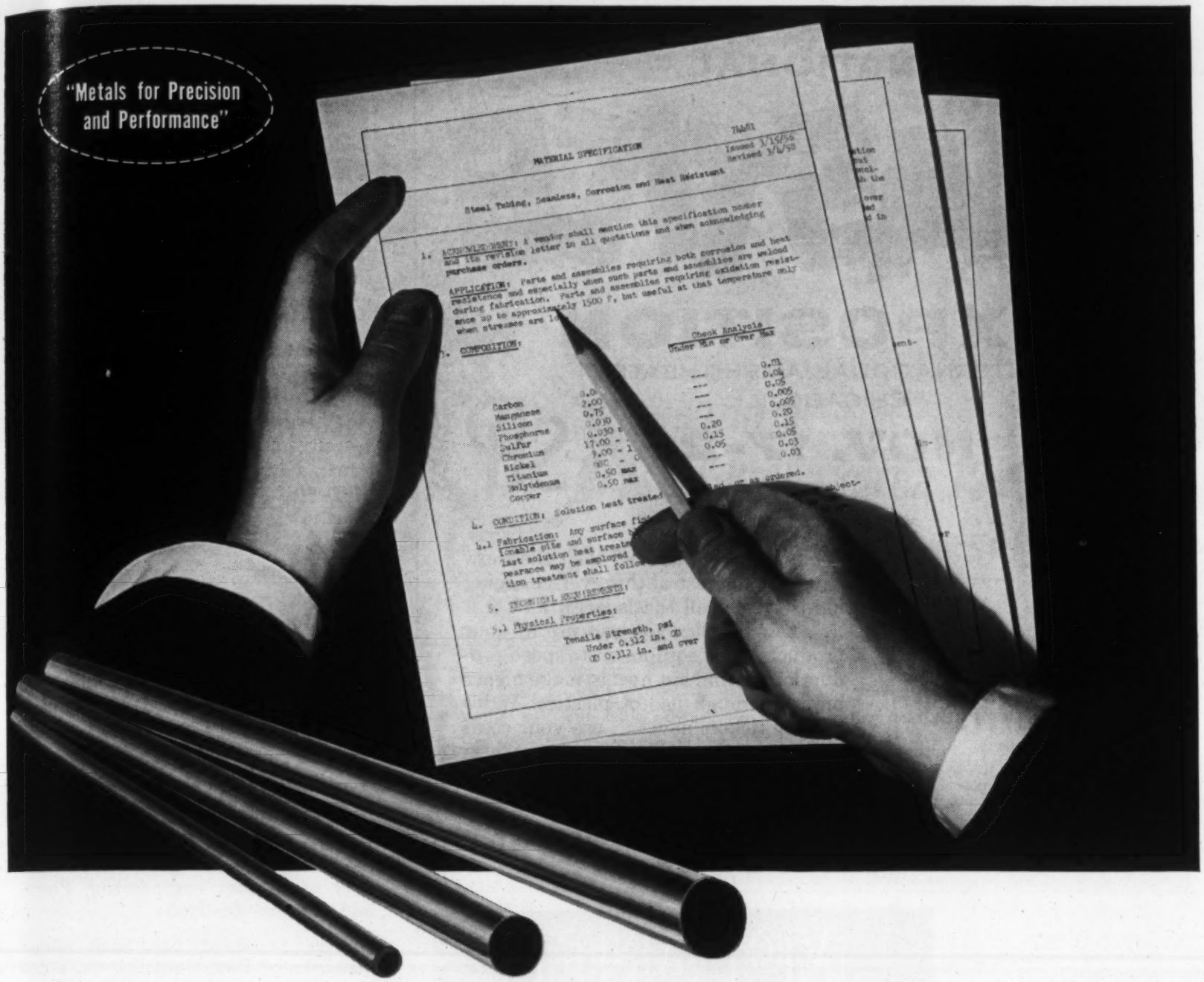

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NICKEL & NICKEL ALLOY TUBING	All standard grades	up to 1.000" OD 0.065" wall max
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GLASS-TO-METAL SEALING ALLOYS	Low expansion alloys for glass sealing applications	
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NOV. 17-21

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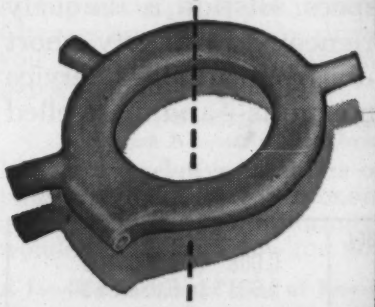
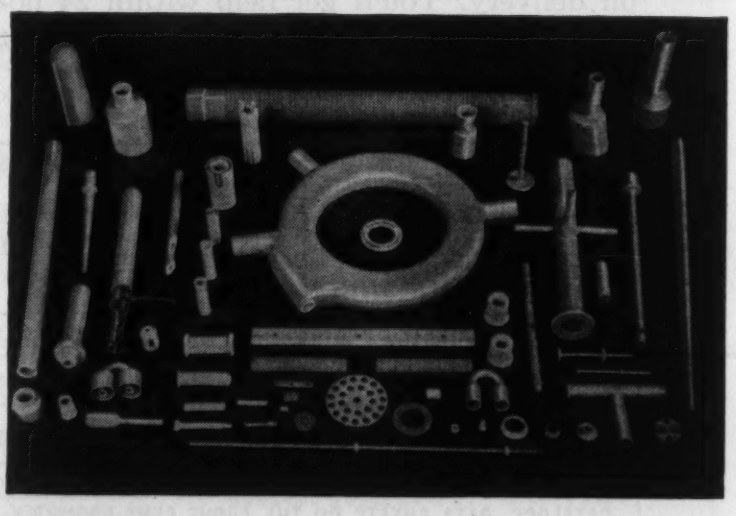


may be your ANSWER



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News OF INDUSTRY

ture service, corrosion and oxidation resistant coatings, and thermal protection systems.

In addition, the Center will provide technical assistance and consulting services on problems involving materials use. The Center will also carry out materials surveys and research on problems specifically authorized by the Assistant Secretary of Defense (for research and engineering).

Engineers

Cortez P. Hackett has been appointed director of research and development, Allied Chemical Corp.

A. N. Kaiser has been named chief engineer, electrical products group, Syracuse Div., Electric Auto-Lite Co.

William E. Pierce has been named to the newly created position of manager of product engineering, Porcelain Enamel Institute.

Hubert Fruehauf has been named manager of Dow Chemical Co.'s new Magnesium Products Dept.

Robert R. Pierce has been named manager, Corrosion Engineering Products Dept., Pennsalt Chemicals Corp.

Leon Weiss has become staff engineer, Electronic Control Systems Div., Stromberg-Carlson Div., General Dynamics Corp.

R. Rex Hartup has been appointed prestress planning engineer, Leschen Wire Rope Div., H. K. Porter Co., **Inc.**

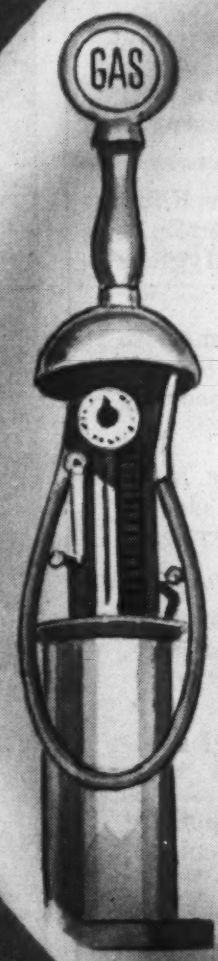
Ward F. Simmons has been appointed chief, High-Temperature Metals Research Div., Battelle Memorial Institute.

Willard J. Harper has been named chief mechanical engineer, and Don-

STANDARDS ARTICLES REPRINTED

The six-part "Guide to Materials Standards and Specifications" which appeared in M/DE, Mar to Aug '58, is now available as an attractive 24-page reprint, as a result of many requests. Cost: 75¢ each in quantities up to 10; 60¢ each for 10 or more. Order from Reader Service Dept.

The Future of Lead...



as seen in a Crystal Ball—circa 1927

"The increased publicity given to the use of ethyl gasoline causes some to think that perhaps herein lies a new outlet of importance for lead . . . In every 1,300 gallons of ethyl gasoline there is approximately one gallon, or 14 lb., of lead tetraethyl, containing about 9 lb. of elemental lead. Present consumption of ethyl gasoline is not known, but an estimate of 750,000,000 gal. a year is sufficiently accurate for this purpose. This would represent an annual consumption of lead in the United States, for making ethyl gasoline, of approximately 2,500 tons, or one-third of 1 per cent of total domestic lead production . . . So the lead miner with an automobile cannot improve his market much by buying ethyl gas; he would do better to paint his house with pure lead paint, have nothing to do with battery eliminators for his radio set, and insist that his power be brought along the street to him in lead-incased cables."

Excerpt from an article "Lead in Ethyl Gasoline" which appeared in the October 29, 1927 issue of Engineering and Mining Journal.

But Here Are The Facts . . .

Last year some 176,000 tons of lead went into the production of tetraethyl lead. The 1927 "Forecaster" could not, of course, foresee that the discovery of tetraethyl lead would usher in a great era of automotive progress by making possible the development of ever-higher compression ratio engines and that thereby, the consumption of lead for this purpose would multiply 70 times between 1927 and 1957.

U.S. CONSUMPTION OF LEAD TETRAETHYL

1927 . . . 2,500 tons **1957 . . . 176,000 tons**

Source: American Bureau of Metal Statistics

Talking About Forecasts . . .

lead because of its density — is the most effective metal for shielding the human body from harmful radiation. Today, the amount of lead used for this purpose is relatively small. Would anyone care to predict how many tons of lead in the form of protective shielding, will be consumed in 1988?

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News OF INDUSTRY

ald G. Dutcher chief electrical engineer, Hanson-Van Winkle-Munning Co.

Ross F. Miller has been named chief engineer, Electronic Systems and Equipment, Nortronics Div., Northrop Aircraft, Inc.

Dr. Miro A. Grottger is now vice president and director of research, Industrial Finishes Co.

John M. Kane, American Air Filter Co., has been elected a director of the American Industrial Hygiene Assn.

Michael Zajac has been named to the newly created position of vice president in charge of engineering, Buhr Machine Tool Co.

Dr. Robert F. Mehl, Carnegie Institute of Technology, has been elected a member of the National Academy of Sciences.

Henry W. Kruschwitz, Jr., has been named manager, technical service, Metal Hydrides Inc.

Irving P. Schwerd is now chief engineer, L. Sonneborn Sons, Inc.

Bela M. Ronay has been appointed consultant in welding technology, Gulton Industries, Inc.

J. Howard Wright has been appointed to the newly created position of technical director, Food and Industrial Machinery Div., Bauer Bros. Co.

Dr. Robert W. Cairns, Hercules Powder Co., has been elected vice president and president-elect of the Industrial Research Institute, Inc.

Companies

Gulton Instrumentation Div. is the new name of Glennite Instrumentation Div., Gulton Industries, Inc.

Charles L. Huisking & Co., Inc., has acquired the assets of **Glyco Products Co., Inc.,** and will form a new subsidiary to be known as Glyco Chemicals Corp.

Peterson Steels, Inc., has formed a new Strip Steel Div., with headquarters at Melrose Park, Ill.

Datex Corp. is the new name for **Giannini Datex Div.,** a subsidiary of

If the cost of metal stampings and wire forms figures in your profit picture, let us give you a quotation on your current components. Send us a sample or blueprint . . . and discover how big savings in time and production costs, big gains in precision and uniformity are possible on small components, when Art Wire tackles the job!

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ART WIRE AND STAMPING CO.

13 Boyden Place, Newark 2, N. J.

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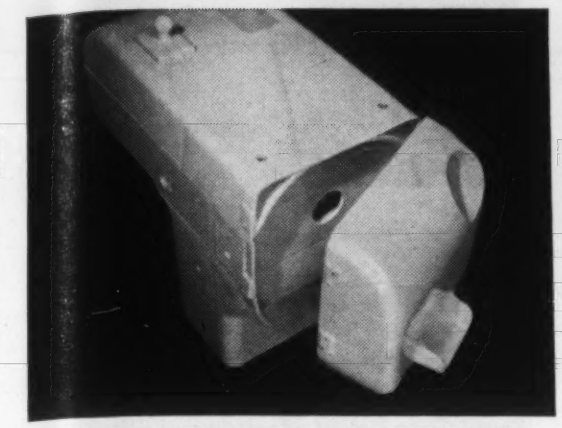
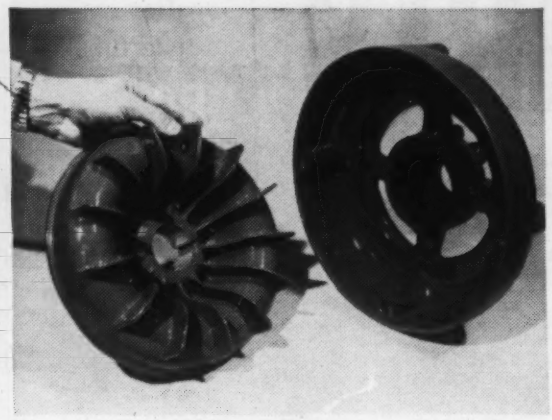
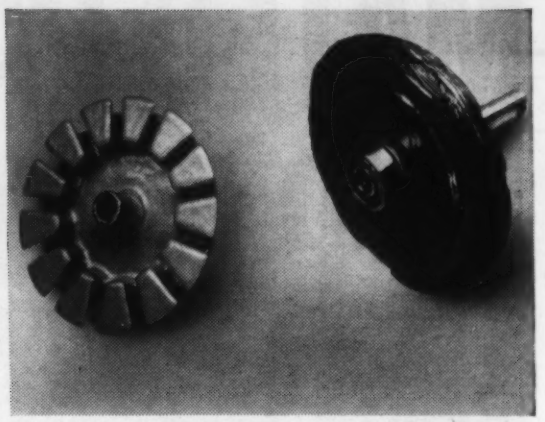


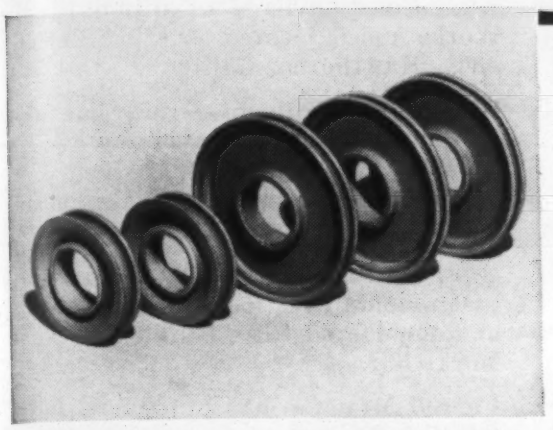
CORVEL Cellulosic Finishes—wide variety of colors with high surface gloss; excellent retention of both color and gloss in water, salt spray, sunlight.



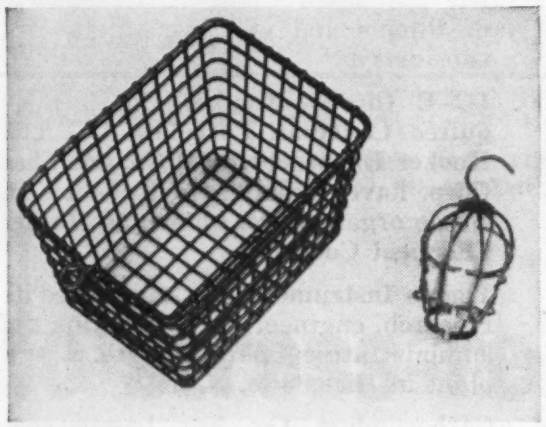
CORVEL Vinyl Finishes—durable with extreme toughness; resistant to corrosion and most chemicals. Available in a range of colors.



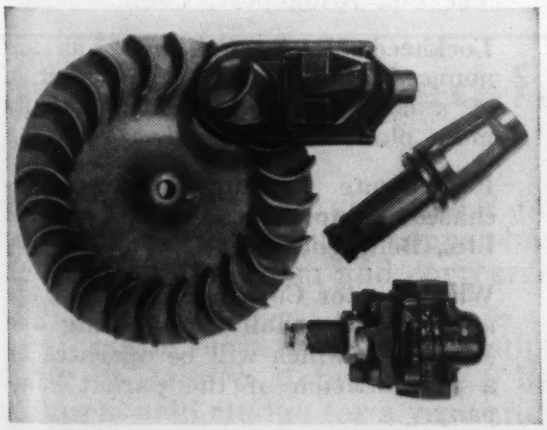
CORVEL Epoxy Finishes—excellent insulation at elevated temperatures; moisture, chemical and impact resistant. Provide a hard, smooth surface.



CORVEL Nylon Finishes—to impart the outstanding wear and low frictional qualities of nylon in coating metals and other base materials.



CORVEL Polyethylene Finishes—provide zero water absorption, excellent chemical resistance and electrical insulation.



CORVEL K-51 Penton Finishes—exceptional chemical and wear resistance. K-51 Penton finishes can withstand temperatures from —40°F. to 250°F.*

*Trademark of Hercules Powder Co.

CORVEL† Fusion Bond Finishes— Six new engineered resins for product finishing

CORVEL finishes are specially processed dry powders, formulated for use in the patented** fluidized bed coating process. These finishes give you the following outstanding advantages:

- Comparatively heavy finishes (from approximately 0.005″ to 0.062″) obtained by a single dipping treatment—*without* the use of solvents.
- Finishes unmarred by sags, drips or bridging.
- Uniformity in thickness, with excellent coverage of sharp edges, corners and projections.

Thus, CORVEL finishes can give your products improved durability and appearance at minimum cost, and provide new design possibilities.

Process licensing is now readily available. A process license is automatically extended to the purchaser of CORVEL powders from National Polymer Products, Inc. upon payment of a small royalty added to each sales invoice. General licenses to use the patented process are available from Polymer Processes, Inc., an affiliate company.

Information relating the advantages of CORVEL Fusion Bond Finishes, to your particular products and details on the fluidized bed process and equipment are available from National Polymer Products, Inc. Write today for a copy of the new CORVEL Bulletin.

NATIONAL POLYMER PRODUCTS, INC.

A subsidiary of The Polymer Corporation

Reading, Pennsylvania

POLYPENCO®

†*Polymer Corporation trademark for finishing materials*

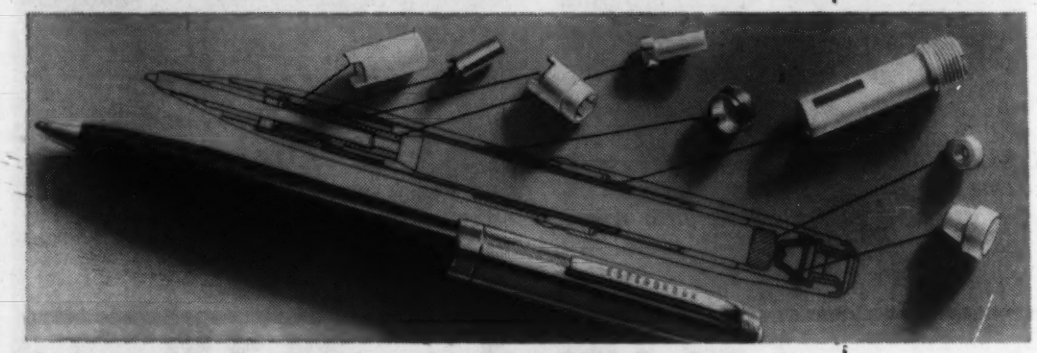
**U. S. Patent 2,844,489 and over 30 patents pending

For more information, turn to Reader Service card, circle No. 519

For more information, turn to Reader Service card, circle No. 490

MATED PARTS help new pen

another wonderful **GRC idea** for designers



8 tiny parts die cast & molded by GRC for Esterbrook precision "mated" to solve the intricate parts problem posed by new-type ballpoint pen

GRC molded 6 tiny parts in nylon and die cast 2 in zinc alloy to form the foundation of the new rotating mechanism evolved by Esterbrook engineers. The uniformity and accuracy of GRC's unique automatic single cavity die casting and molding methods made possible the precision mating of tiny parts, eliminated the necessity of selective assembly, assured trouble-free operation of the assembled pen, and again provided a new dimension to designers faced with a difficult situation.

Write for detailed bulletins or send prints for quotation. Quick deliveries on quantities of 25,000 to millions.

NO SIZE TOO SMALL!

Maximum size:
Zinc Alloy
½ oz. 1¾",
Plastic
.03 oz. 1¼"

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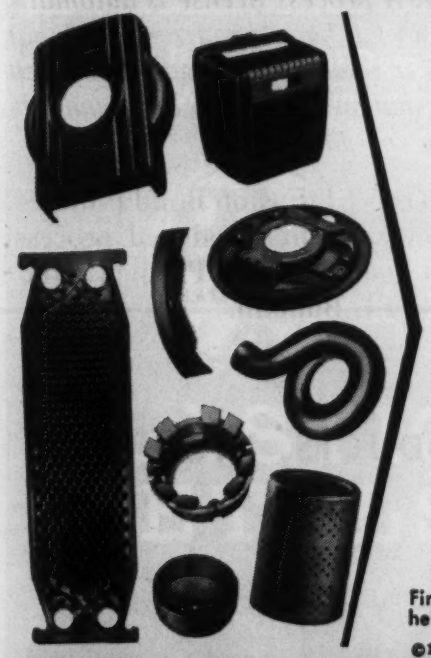
Production costs too high?

BOSSERT METAL STAMPINGS

offer many ways to reduce costs!



Whether your product is in the planning stage or in production, you can often reduce costs by using metal stampings for parts or complete assemblies. Complex forms can usually be produced with fewer operations, with holes punched to exact dimensional accuracy, eliminating separate drilling, machining and assembling.

Several parts can be combined in a single stamping, and you can take advantage of the weight-saving features of lighter metals and alloys without sacrificing strength or durability. Your present production costs can be reduced, too, with Bossert's superior quality and dependable service.

Design Engineering Service

Bossert's re-design service can help you develop stampings for parts and assemblies that are now being cast or forged or machined, usually with substantial savings in cost. Send us blue prints or samples for our recommendations.

Write for literature
Find out how our facilities can be helpful to you.

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ROCKWELL R STANDARD

ROCKWELL-STANDARD CORPORATION
STAMPING DIVISION
1010 OSWEGO STREET UTICA, NEW YORK

For more information, turn to Reader Service Card, circle No. 452

News OF INDUSTRY

G. M. Giannini & Co., Inc., and is located in new offices at 1307 S. Myrtle Ave., Monrovia, Calif.

U. S. Rubber Co.'s Textile Div. has formed a new Industrial Textiles Dept. as the beginning of an expansion program in the industrial textiles field.

Calinoy Div. is a recently established West Coast division of **Illinois Tool Works** and is located at 12917 Cerise Ave., Hawthorne, Calif.

Beckman Instruments, Inc., has acquired the assets of its wholly owned subsidiary, **Helipot Corp.,** which will operate as a division of Beckman.

W. L. Maxson Corp. has established two new divisions, **Langevin Div.** and **Instruments Div.,** located respectively at Long Island City, N. Y., and New York City.

Farrell Mfg. Co. has purchased **Indiana Oil Equipment Co.**

American-Marietta Co. has acquired **Southern Dyestuff Corp.**

Cleveland Pneumatic Industries, Inc., has purchased **Claud S. Gordon Co.** of Illinois and will operate it as a subsidiary.

I-T-E Circuit Breaker Co. has acquired **Canadian Porcelain Co., Ltd. Hooker Electrochemical Co.** and **Shea Corp. have** consolidated to become a single organization known as **Hooker Chemical Corp.**

Tempo Instrument Inc. has moved its research, engineering, production and administrative operations to a new plant in Hicksville, N. Y.

Carborundum Co. has begun construction of a new $6-million plant in Niagara Falls.

National Tool Co. has acquired **Auto-Vac Co.,** Bridgeport, Conn.

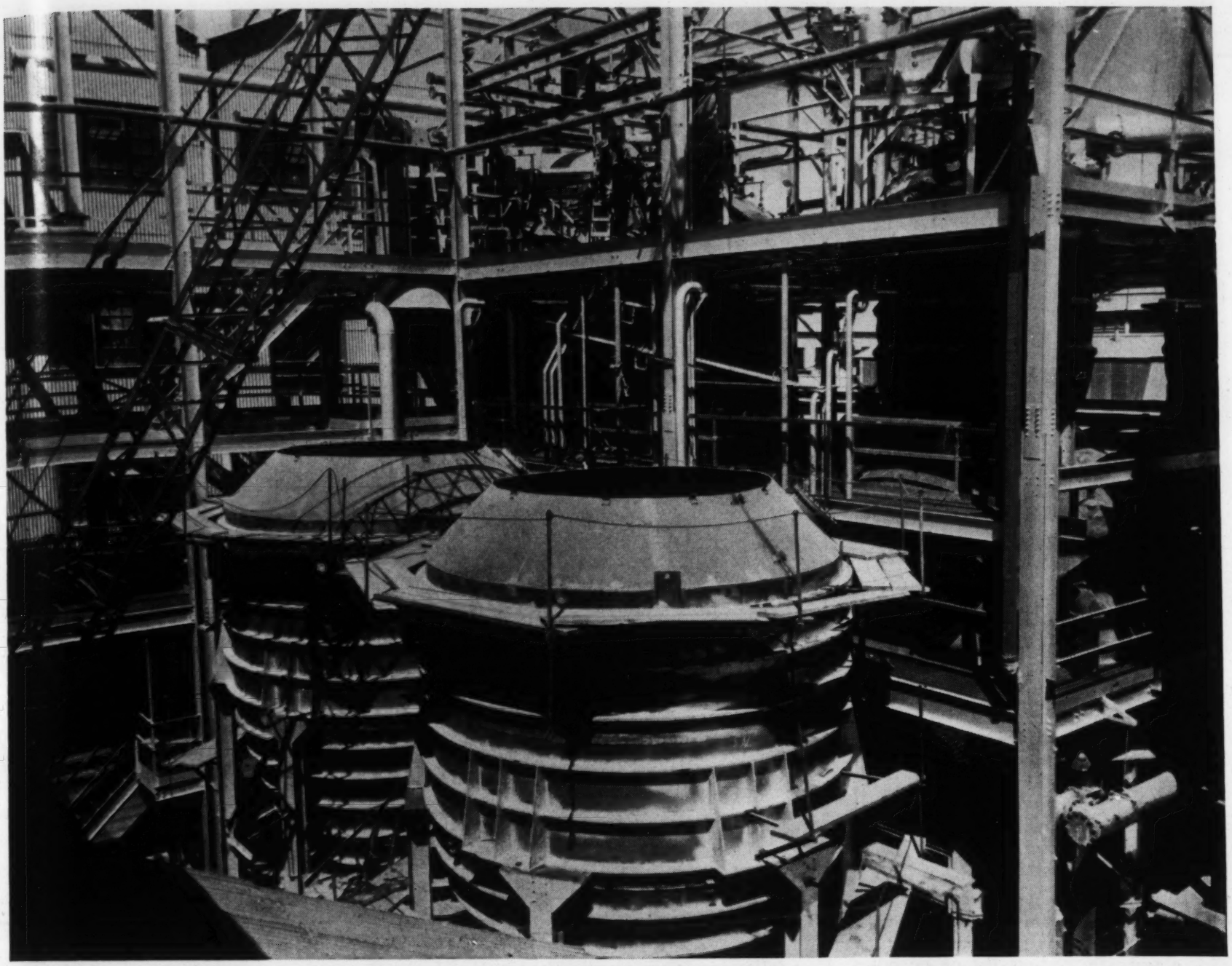
Lockheed Missile Systems has announced plans for the construction of a new $7-million addition to its main plant in Sunnyvale, Calif.

Permanente Cement Co. has purchased **Olympic Portland Cement Co., Ltd.,** Bellingham, Calif.

Wheelabrator Corp. has acquired the assets of **Crandall Engineering and Mfg., Inc.,** which will be operated as a new division of the parent company.

Michigan Chemical Corp. has completed plans for the construction of a new sea water magnesia plant at Port St. Joe, Fla.

(News of Societies on p 214)



The potash crystallizers under construction above are two of seven that were shop- and field-fabricated, then field-assembled by welding. Although these units were not stress-relieved or heat-treated, there was no sign of stress-corrosion cracking after a year.

No stress-relieving here —no stress-corrosion cracking!

Field-assembled from NEW AMPCO METAL GRADE 8

Improved Ampco Metal Grade 8 puts an entirely new slant on fabricating copper-base alloy equipment to handle steam and corrosive media at elevated temperatures.

At a major oil refinery, for example, field-welded piping of Ampco Metal Grade 8 has handled hot sulphuric-acid sludge for a year and a half without stress-corrosion cracking.

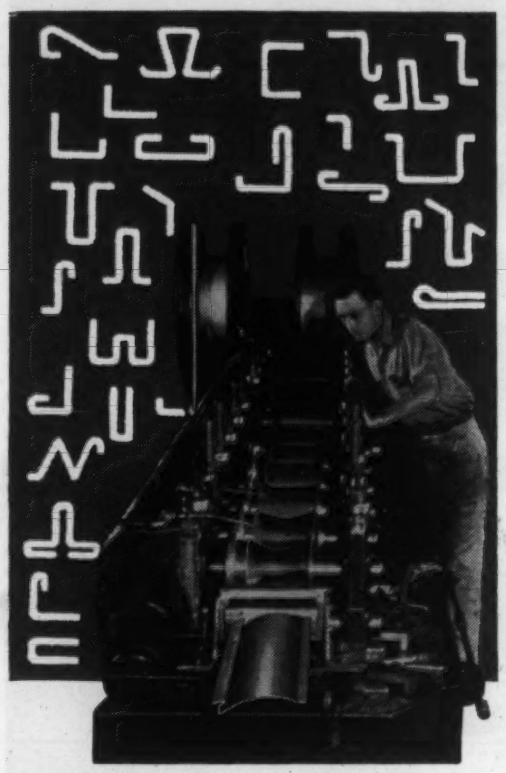
New, patented Ampco Metal Grade 8 also simplifies field repairs and alterations. You can weld readily with any electric process, without pre-heat or post-heat and without hot-short cracking.

Talk this over with your Ampco field engineer. Or write *Ampco Metal, Inc., Dept. 11K, Milwaukee 46, Wis. West Coast plant: Burbank, Calif.—Southwest plant: Garland (Dallas County), Texas.*

TS-6

AMPCO®

For more information, turn to Reader Service card, circle No. 496



With a YODER... ONE MAN PRODUCES 30,000 FEET OF SHAPES A DAY!

Cold-roll forming with a Yoder Roll-Forming machine makes spectacular production possible in many metalworking applications and industries.

A multitude of shapes, simple or complex, produced from a wide variety of coated or uncoated stock, and destined for a virtually endless list of purposes, can be easily, quickly and economically produced with a Yoder cold-roll forming machine.

Whether it be moldings, structurals, siding, roofing, tubulars, cabinet shells, or any one of a thousand requirements, it can be quickly produced with accuracy and uniformity the Yoder way. The conversion cost is usually so low that even part-time operation makes a Yoder cold-roll forming line a profitable investment.

A great many modifications of the basic shape such as welding, coiling, ring forming, notching, perforating, embossing and cutting to length, can be simultaneously introduced with little or no additional labor cost. It will pay you big dividends to fully investigate the advantages of Yoder cold-roll forming. A fully-illustrated, 88-page book clearly discusses every important aspect of this amazingly versatile method of metal fabrication... it is yours for the asking.

THE YODER COMPANY
5546 Walworth Ave. • Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING COLD ROLL FORMING MACHINES

For more information, circle No. 381

News OF INDUSTRY

Societies

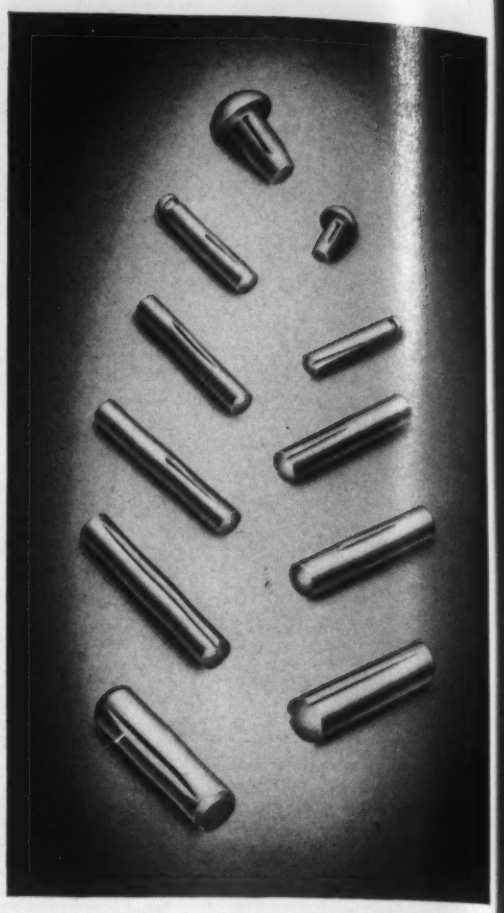
American Society for Metals has appointed the following men to positions on the National Advisory Council of the Metals Engineering Institute: James B. Austin and Edgar C. Bain, U. S. Steel Corp.; Arthur E. Focke, General Electric Co.; Francis B. Foley, International Nickel Co., Inc.; W. E. Jominy, Chrysler Corp.; George A. Roberts, Vanadium-Alloys Steel Co.; Adolph O. Schaefer, Pencoyd Steel & Forge Co.; B. F. Shepherd, Ingersoll-Rand Co.; Kent R. Van Horn, Aluminum Co. of America; Ralph L. Wilson, Timken Roller Bearing Co.; and Harold K. Work, New York University.

Lead Industries Assn. has elected the following officers: president & chairman of the board—John D. Bradley, Bunker Hill Co.; vice presidents —F. S. Mulock, U.S. Smelting, Refining & Mining Co.; Felix Edgar Wormser, St. Joseph Lead Co., and Kenneth W. Green, Electric Storage Battery Co.; and secretary-treasurer —Robert L. Ziegfeld.

Alloy Casting Institute announces the following officers: president—Paul L. McCulloch, Jr., American Brake Shoe Co.; vice president—J. B. Dear, Duraloy Co.; and executive vice president and treasurer—E. A. Schoefer. New members of the board of directors are: E. H. Platz, Jr., Lebanon Steel Foundry; and J. S. Woosters, General Alloys Co.

American Zinc Institute has re-elected the following officers: president—S. D. Strauss, American Smelting & Refining Co.; vice presidents—J. D. Bradley, Bunker Hill Co.; Clarence Glass, Anaconda Sales Co.; and H. L. Young, American Zinc Sales Co.; treasurer — G. H. LeFevre, U. S. Smelting, Refining & Mining Co.; and executive vice president and secretary—J. L. Kimberley. Directors are: H. D. Carus, Matthiessen & Hegeler Zinc Co.; C. M. Chapin, Jr., St. Joseph Lead Co.; R. G. Kenly, New Jersey Zinc Co.; E. H. Klein, New Jersey Zinc Co.; J. J. Lennon, American Metal Climax, Inc.; F. S. Mulock, U. S. Smelting, Refining & Mining Co.; R. F. Orr, Athletic Mining & Smelting Co.; O. A. Rockwell, Eagle-Picher Co.; C. N. Waterman, American Smelting & Refining Co.; and H. L. Young, American Zinc, Lead & Smelting Co.

(News of Meetings on p 216)



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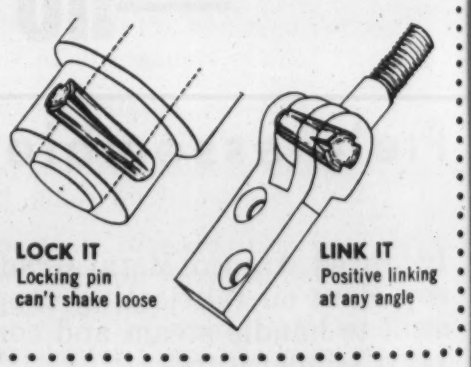
THE SOLID GROOV-PIN

Every one of the Groov-Pins shown here was designed with your pin problems in mind. Designed to withstand the rigors of constant shock and vibration without loosening...to drive easily into a simple drilled hole...for faster hand or production feeding, including hopper feed...for a permanent connection that stands up to vibration fatigue as only a solid pin can.

Groov-Pins are made to meet your requirements, too. Standard sizes run from 1/32 to 1/2", specials to fit your needs at standard prices over 5,000 pieces. Send for illustrated catalog, free samples.



No matter what your pin problem, there's a Groov-Pin to solve it for you.

GROOV-PIN CORPORATION
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For more information, circle No. 488

"Surface Finish On These Clips Has To Be SUPERIOR!"

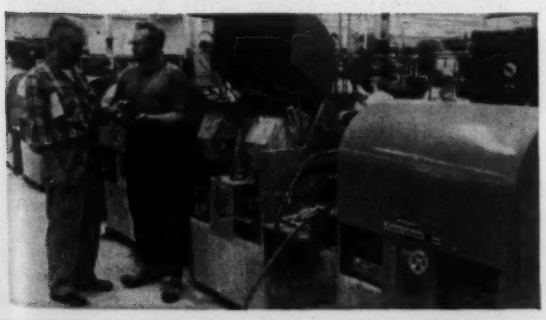
Robert Daly, Finishing Supervisor, holds sparkling Arrow pen clips finished in one of the nine ALMCO barrel finishing machines used by The Parker Pen Company.

BECAUSE THE ARROW is a trademark of The Parker Pen Company, the surface finish on each of these distinctive pen clips has to be more than just good. *It has to be superior!* What's more, production must be high and costs must be low.

That's why The Parker Pen Company now has *nine* ALMCO precision barrel finishing machines running *around the clock* in their parts deburring and finishing department. Used for cutdown operations, descaling after heat treatment, deburring and polishing, the scientific ALMCO Supersheen method helps the Parker people to meet high standards of quality, reduce costs and increase production, simultaneously!

Perhaps ALMCO finishing methods can do as well for you. It's no trick at all to find out. Just write us on your letterhead asking for an ALMCO sales engineer to call. Or, send sample parts and specifications on results desired direct to ALMCO's main laboratory at Albert Lea, Minnesota.

Meanwhile, send today for your FREE 52-page SUPERSHEEN barrel finishing handbook. Profusely illustrated.



Even though the nine ALMCO machines are in use 24 hours a day at Parker Pen, operators report that little maintenance is required to keep them in top-notch working order. That saves money, too!

ALMCO

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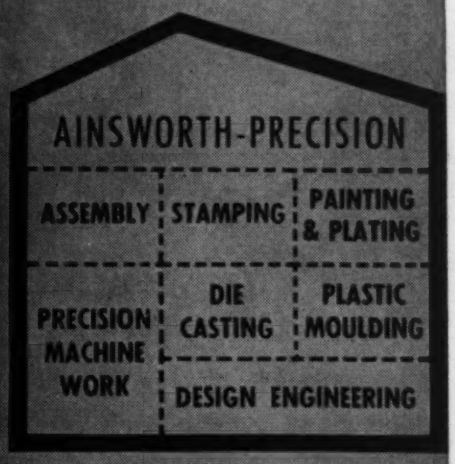

Design and production specialists—working with your engineers—can help select the proper materials and methods, eliminate production "bugs." Note: Since we have most fabrication facilities, they render impartial judgment. They point out the best way to make your product – expense-wise and quality-wise. Some of the products we've helped design and manufacture: Thunderbird steering column, airforce nuclear bomb rack, electric fry pans, Imperial window assemblies, drive-in theater car heaters, Colt pistol.

Write, phone or wire Ainsworth-Precision Castings Co., 3200 Guardian Bldg., Detroit 26, Mich. Plants at Detroit, Marysville, Kalamazoo, Mich.; Fayetteville and Syracuse, N. Y.; Chicago and Rockford, Ill.; Cleveland. Ohio; Springfield. Tenn.

AINSWORTH-PRECISION
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News of Industry

Meetings

NATIONAL TOOL & DIE MFRS. ASSN., annual convention. Philadelphia. Nov 5-9.

STEEL FOUNDERS' SOCIETY OF AMERICA, 13th annual technical and operating conference. Cleveland. Nov 10-12.

NATIONAL ELECTRICAL MFRS. ASSN., annual meeting. Atlantic City. Nov 10-13.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, annual meeting. Albany, N. Y. Nov 12-14.

4TH CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS, American Institute of Electrical Engineers, American Physical Society, Institute of Radio Engineers, Metallurgical Society of AIME, and Office of Naval Research. Philadelphia. Nov 17-20.

8TH NATIONAL PLASTICS EXPOSITION AND ANNUAL CONFERENCE, Society of the Plastics Industry, Inc. Chicago. Nov 17-21.

AMERICAN STANDARDS ASSN., 9th national conference. New York City. Nov 18-20.

NATIONAL FOUNDRY ASSN., annual meeting. Chicago. Nov 20-21.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, annual meeting. New York City. Nov 30-Dec 5.

AMERICAN ROCKET SOCIETY, INC., 13th annual meeting. New York City. Dec 1-5.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS, electric furnace steel conference. Detroit. Dec 3-5.

RUBBER & PLASTIC ADHESIVE & SEALANT MFRS. COUNCIL, meeting. Washington, D. C. Dec 8-9.

AMERICAN NUCLEAR SOCIETY, 1st annual meeting. Detroit. Dec 8-10.

5TH NATIONAL SYMPOSIUM ON RELIABILITY AND QUALITY CONTROL, American Society for Quality Control, Institute of Radio Engineers, American Institute of Electrical Engineers, and Electronic Industries Assn. Philadelphia. Jan 12-14, 1959.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter general meeting. New York City. Jan 19-24, 1959.

SOCIETY OF PLASTICS ENGINEERS, INC., 15th SPE annual technical conference. New York City. Jan 27-30, 1959.

Nuclear Graphite is a Specialty at GRAPHITE SPECIALTIES CORP.

• High strength, fine texture and extra pure grades of Graphite Specialties graphite are available for lowest neutron-capture cross section. In addition, high scattering cross section and increasing strength at high temperature makes this material suitable for use in nuclear reactors as moderator, reflector, fuel elements, structural parts and piping.

• Graphite Specialties Corp. also furnishes custom formulated grades of graphite for mechanical, metallurgical and processing applications, as well as for high temperature electric furnaces.

• "Graph-I-Tite" is one of the standard formulations available. It is the first impervious graphite. It is immune to thermal shock, non-contaminating, not wetted by molten metals, and is unaffected by practically all corrosives, even at temperatures above 1,000°F.

• Most types of Graphite Specialties graphite can be molded, extruded or machined to close tolerances, and are available as finished components, or in rod tube, sheet, block or rough extruded or molded form.

• Don't let old fashioned materials restrict your thinking. If you have an "ordinary" materials problem, or one such as heating dry chlorine up to 5000°F., write to GRAPHITE SPECIALTIES CORPORATION 64th & Pine Avenue, Niagara Falls, New York.

For more information, circle No. 493

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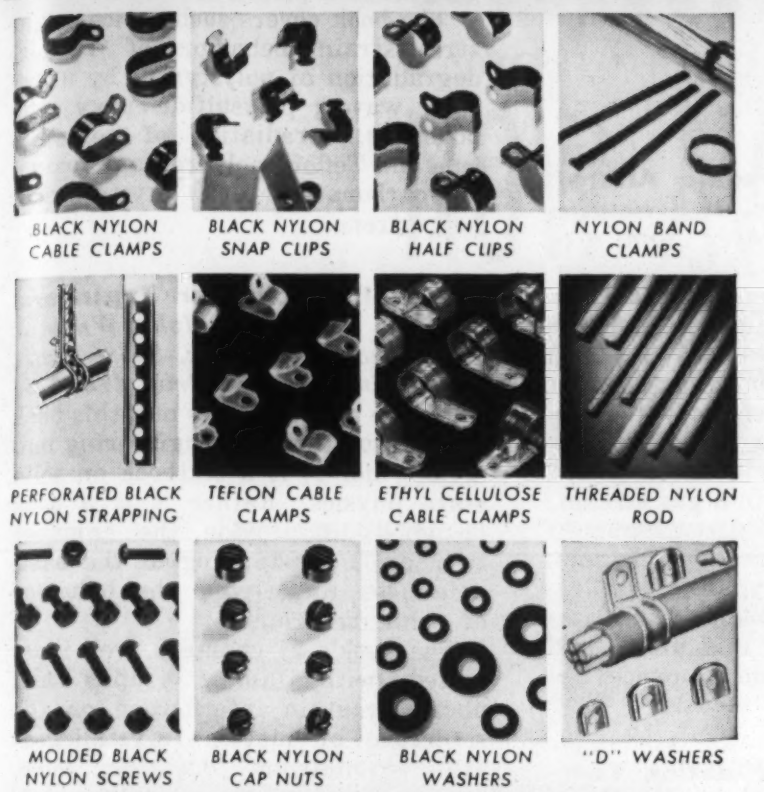
Weckesser Plastic Products



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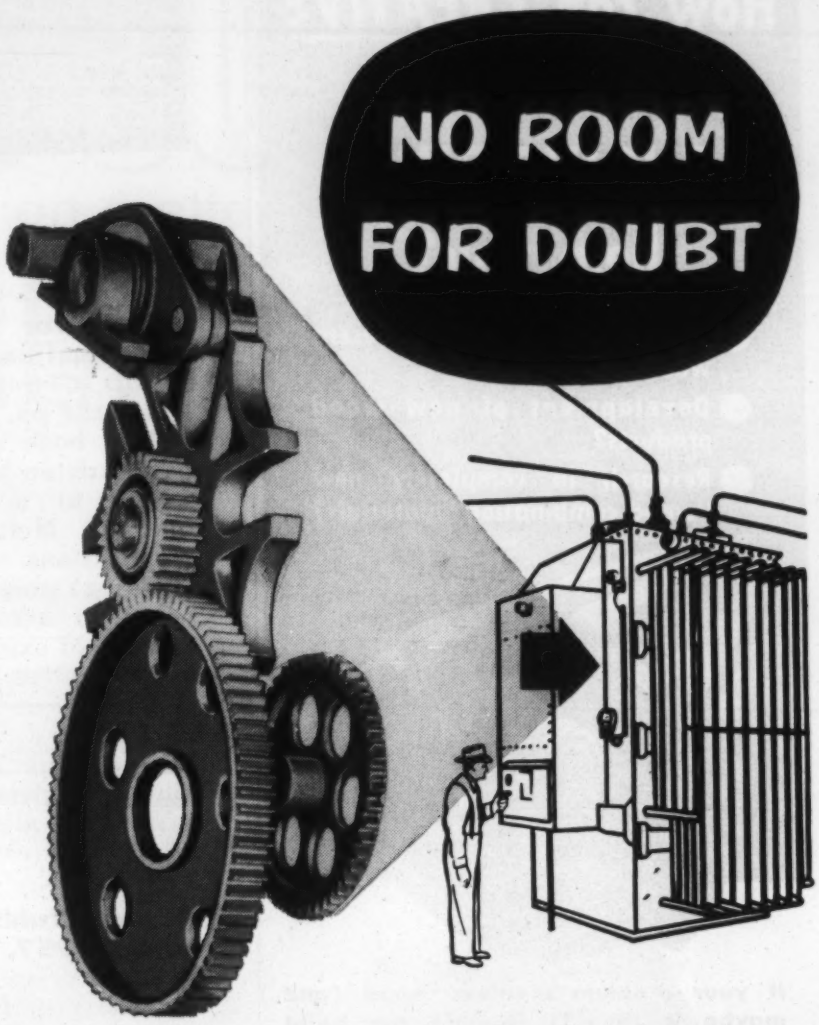

Gears in this Geneva gear drive have to be rugged! They change taps to correct voltage in General Electric high capacity step voltage regulators, where failure could affect the performance of millions of dollars worth of electrical equipment in homes and plants.

Yet, specifications called for thin wall sections and fine tolerances.

Atlantic Casting engineers, working with the engineering department of the General Electric Company, produced gears and drivers to specifications, and all Atlantic-cast components were tested through millions of split-second tap changing operations.

Results of tests? NOT ONE FAILURE!

Atlantic Casting proved itself again, and Atlantic-Cast gears and drivers are now used by the General Electric Company in step voltage regulators of up to 69,000 volts capacity.

➡ **SEND NOW** for Atlantic Casting and Engineering's new catalog and find out how casting the Atlantic way can improve your product and reduce costs.

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If your problem involves wood (and maybe it should) Gamble can help! Gamble Brothers' 65 years of creative wood engineering has greatly expanded the usefulness of America's great renewable resource. Gamble has pioneered new processes and new products involving wood-and-fiberglass, wood-and-plastic, wood-and-metal, wood-and-synthetics and countless others. Perhaps our technical knowledge of the properties of more than 130 commercial wood species, and the creative application of this knowledge to today's design and development problems could be of service to you.

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GAMBLE BROTHERS
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Louisville 9, Kentucky

TECHNICAL LITERATURE

(cont'd from p 43)

Books

Metals for Supersonic Aircraft and Missiles. *American Society for Metals, Cleveland, 1958. Cloth, 6 by 9 in., 423 pp. Price $7.50*

This book contains technical papers written by 22 authors and presented at a conference on Heat tolerant Metals for Aerodynamic Applications. Subjects covered include: 1) metals for structures exposed to aerodynamic heating; 2) kinetics of oxidation in a gas stream; 3) protective metallic coatings; 4) fundamentals of metal-ceramic combinations; 5) areodynamic applications of aluminum, magnesium, titanium, stainless steel and nickel and cobalt-base alloys; and 6) properties of 11 less common metals.

Resins, Rubbers, Plastics Yearbook: 1957. *Edited by H. Mark, E. S. Proskauer and V. J. Frilette. Interscience Publishers, Inc., New York, 1957-1958. Cloth, 7 by 10 in., 1144 pp. Price $35.*

Illustrated with tables and graphs, this book is a collection of abstracts of domestic and foreign papers published during 1957 dealing with the properties and behavior of resins, rubbers and plastics.

The book covers such topics as the stress-strain behavior of rubber; degradation of polystyrene by ultrasonic waves; polysulfide-epoxy compositions; irradiation of polyethylene and Teflon; polyurethane foams; polycarbonates; and crystallizable polystyrene.

The Solid State for Engineers. *Maurice J. Sinnott. John Wiley & Sons, Inc., New York. 1958. Cloth, 6 by 9 in., 533 pp. Price $12.50*

As the author points out, this book is not a textbook on engineering materials, nor is it a textbook on solid state physics. Rather it is a book designed to provide the engineer with an understanding of the basic principles underlying the behavior of solid materials.

The book's 21 chapters, well illustrated with tables, graphs and photos, contain information on the structure of matter; crystallography; equilibrium; metallic, ionic, covalent, molecular and polycrystalline solids; mechanical, thermal, electronic, magnetic and optical properties of solids; electron and

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Udimet 500

a vacuum induction melted alloy

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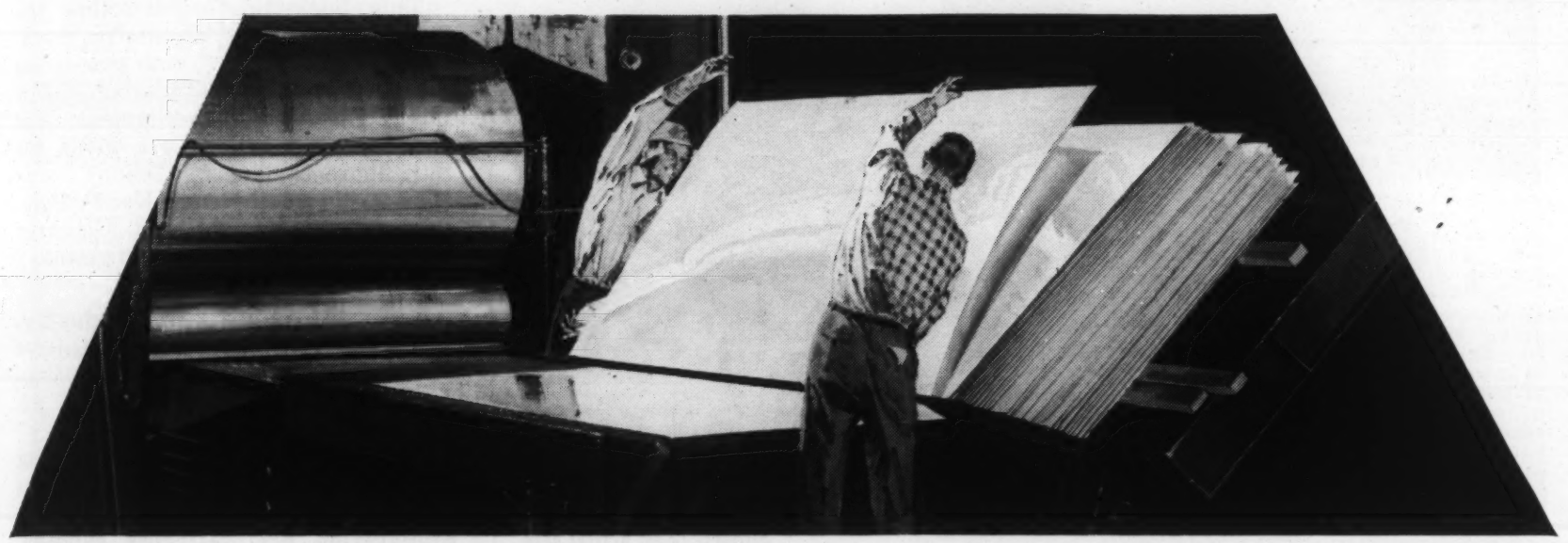

Udimet 500, a superior alloy proven by extensive high temperature applications, is now available in sheet in production quantities for early delivery. It is produced in widths to 48″ by 144″ in length and in thickness down to .010″. The alloy combines very high stress rupture life with excellent ductility and fatigue resistance in the 1200°F to 1800°F ranges.

Many other vacuum induction melted alloys are also now marketed in sheet form by the Utica Metals Division.

New alloys are being developed at Utica for critical sheet application. We are interested in discussing uses for our sheet material where high tensile strength, corrosion resistance, high stress rupture life and electrical or magnetic properties are critical requirements.

The technical strength and experience of our organization, together with highly precise melting and inspection practices, enable us to guarantee absolutely consistent quality from heat to heat. Utica Metals Division, Kelsey-Hayes Co., Utica 4, N. Y.

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Shown 1/20 actual size

HACKNEY shapes save for missile producers, too!

The Hackney Method of producing components by deep drawing cold steel, widely used in many industries, produces missile parts economically.

Hackney produced components give engineers more latitude for solving design problems. Savings can be made in over-all weight, assembly time, and through elimination of nonessential parts.

Hackney deep drawn seamless parts provide maximum strength with minimum weight, resist both internal and external pressures.

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The Hackney Method may be the answer to some of your stubborn production problems. Let us know what you want to do. A simple sketch will be helpful. Since we work in steel, stainless steel, nickel, aluminum, magnesium, copper and alloys, add a note about the metals you have in mind. Our engineers will have some practical ideas to send you. Write:

Pressed Steel Tank Company

Manufacturer of Hackney Products

1442 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

Hackney MILWAUKEE — DOWNINGTOWN IRON WORKS INC. DIVISION

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TECHNICAL LITERATURE

zone theories; and miscellaneous surface phenomena.

Mr. Sinnott, professor of chemical and metallurgical engineering at the University of Michigan, is a recipient of the American Society for Metals award for outstanding teaching.

Fluorocarbons. *Merritt A. Rudner. Reinhold Publishing Corp., New York, 1958. Plastics Applications Series. Cloth, 5 by 7 in., 240 pp. Price $5.75.*

This book briefly describes the history, properties, chemistry, method of manufacture, and processing characteristics of fluorocarbon materials. Electrical, mechanical and chemical applications are given for tetrafluoroethylene (Teflon) and chlorotrifluoroethylene (Kel-F, Polyfluoron, fluoroethene and Genetron HL) and filled fluorocarbon resins.

Paint Finishing in Industry. *A. A. B. Harvey. Robert Draper Ltd., Teddington, Middlesex, England, 1958. Cloth, 6 by 9 in., 532 pp. Price $12.*

Concerned with the paint finishing of metal and wood products, this book gives information on surface preparation, pretreatments, sanding, polishing, lining, flock finishing and silk screen printing. A number of chapters are devoted to the finishing of automobile bodies, refrigerators, machinery and castings. Paint testing is covered in detail. British and U. S. paint specifications are given.

Reports

Standards for ceramics. STANDARDS OF THE STEATITE MANUFACTURERS ASSN.: 1ST EDITION. *1958. 24 pp. Steatite Mfgrs. Assn., 53 Park Pl., New York 7. Price $1.*

Gives scope and properties of electronic-grade ceramics, manufacturing standards, dielectric and flexural strength tests, and definitions. Four appendices give design information.

Failure of steel HYDROGEN, CRACK INITIATION, AND DELAYED FAILURE IN STEEL. *H. H. Johnson, J. C. Morlet and A. R. Troiano, Case Institute of Technology. May '57. 52 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.50 (PB 131340)*

According to this report, crack initiation in hydrogenated steel may

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BORON NITRIDE An easily machined, impermeable ceramic material with unique electrical and corrosion resistance properties for use up to 3000 F.	Density, gms/cc — 2.10 min. (true density, gms/cc — 2.25); working temperature: inert atmosphere, solid — 3000°F. max.; powder — 5000°F. max.; oxidizing atmosphere, solid — 1800°F. max.; powder — 1300°F. max.; dielectric constant — 4+; dielectric strength — high; electrical resistivity — high; coefficient of friction — low; thermal shock resistance — excellent; permeability — negligible; flexural strength — good; hardness, Moh's scale — 2.	Can be machined at high speeds without lubricant with standard steel cutting tools. May be threaded or otherwise physically joined to form strong, sizeable assemblies.	Solid and powder form. Has hexagonal crystalline structure similar to graphite.	Vacuum tube separators; dielectric applications; electrical insulators; chemical equipment parts; molten metal pump parts; combustion chamber liners; melting crucibles; thermocouple protection tubes; mold release agents; gaskets; seals; rupture discs.
KT SILICON CARBIDE Extremely hard, self-bonded impermeable ceramic for use up to 4000 F.	Very hard; negligible permeability; exceptional abrasion and corrosion resistance; working temperature to 4200 F in inert atmosphere, to 3000 F in oxidizing atmosphere; high modulus of elasticity, flexural strength, compressive strength, thermal conductivity; low thermal expansion; excellent resistance to thermal shock.	Standard ceramic forming techniques can produce large intricate shapes to .007" tolerance on unground surfaces and to .001" on ground surfaces. Diamond grinding necessary for finish machining, can produce very high surface finish (5 micro-inches).	Solid form.	Wear-resistant parts; crucibles; heat exchanger parts; valves for corrosives; pipe and fittings; nuclear reactor structural parts; rocket nozzles; nose cones; leading edges.
FIBERFRAX® A fibrous insulation medium above the practicable temp range of mineral wool, glass & asbestos.	Melting point over 3000 F; maximum use temp 2300 F; low thermal conductivity; castable forms exhibit exceptional thermal shock resistance.	Extremely diverse fabricating possibilities due to wide variety of forms available.	Bulk; long & short staple fiber; batts; board; paper; blocks; castable compositions; molded shapes; roving; yarn; wicking; rope; tape; cloth; braid.	Thermal, acoustical and electrical insulation; high temperature gas filters; gaskets; packings; liners for aluminum pouring troughs; vacuum outgassing of reactive metals; protective cushion in honeycomb brazing; protective coatings for metals and graphite.
REFRAX® Silicon-nitride-bonded silicon carbide.	Average bulk density: 2.87; porosity: 7.9%; thermal conductivity @ 2200 F: 113.5 Btu; modulus of rupture @ 1350 C: 5640; excellent abrasion resistance; very high relative resistance to spalling; not wet by molten silver, copper or aluminum; good thermal shock resistance.	Can be formed into complex shapes with tolerances as low as .005"/in. possible without finish grinding. For closer tolerances, lap or grind with diamond abrasives; drill or bore with ultrasonic methods.	Brick and shapes in many instances resembling metal in characteristics.	Brazing fixtures; pumps and pump parts for aluminum and other nonferrous metals; burner tips; nozzles and blocks; cyclone-type classifier parts exposed to abrasive materials suspended in liquid and gas carriers; acid spray nozzles.
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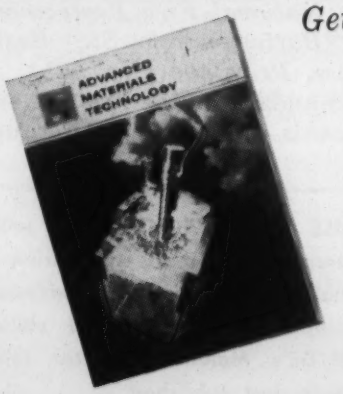

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TECHNICAL LITERATURE

be caused by a critical combination of hydrogen concentration and triaxial stress. With mild notches, cracks began to appear well below the notch surface. Fracture stress is constant over a wide range of hydrogen concentrations and applied stresses.

Polyethylene, polypropylene. LINEAR POLYETHYLENE AND POLYPROPYLENE: PROBLEMS AND OPPORTUNITIES. *1958. 177 pp. Polymer Assoc., 6613 Wenonga Rd., Kansas City, Mo. Price $13.50.*

Includes property comparisons of linear polyethylene and polypropylene with other plastics. Gives case histories of fabricators' experiences with polyethylene and polypropylene and outlines the use of these materials in a number of industries.

Steel casting design. A PRACTICAL GUIDE TO THE DESIGN OF STEEL CASTINGS. *British Steel Castings Research Assn. 1958. 54 pp. Available from Penton Publishing Co., Penton Bldg., Cleveland 13. Price $1.75.*

The four chapters in this report are concerned with 1) properties of cast steel; 2) foundry defects attributable to bad casting design; 3) design rules independent of the direction of molding and pouring; and 4) design rules dependent on pouring and molding.

Structural adhesives. STRUCTURAL ADHESIVES: AN INTRODUCTION FOR POTENTIAL USERS. *1958. 68 pp. Structural Adhesives Assoc., 907 N. 17th St., Allentown, Pa. Price $9.50.*

Information on the funamental concepts of adhesion, the practical aspects of adhesives and bonding, and the uses of adhesives in the aircraft, automotive and other metalworking industries. Gives names and addresses of adhesive manufacturers.

Handling titanium STANDARD FOR PRODUCTION, PROCESSING, HANDLING, AND STORAGE OF TITANIUM. *1958. 32 pp. National Fire Protection Assn., 60 Batterymarch St., Boston 10, Mass. Price 50¢ (No. 481)*

Standard on the fire and explosion hazards associated with titanium.

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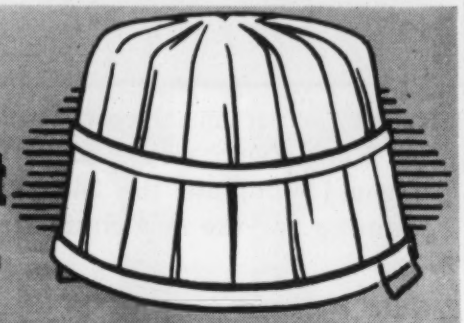

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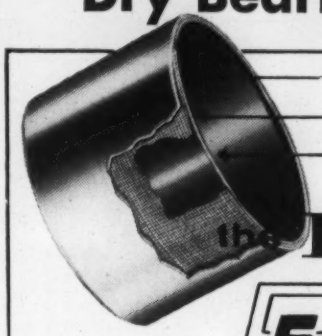

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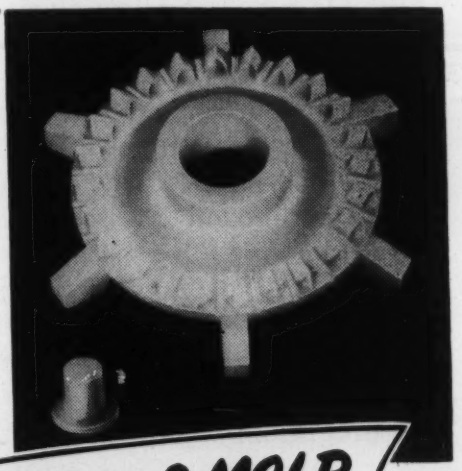

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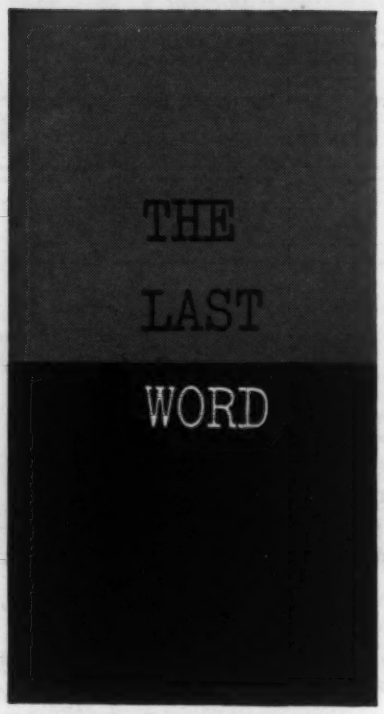

by ***H. R. Clauser***
Editor

A Machine That Talks Our Language

If you're the kind of person whose eyes swim when you look at a long tape from a computer that reads like this: 100110, 000101, 010101, 100111, etc., you'll be happy to hear, as we were, that Remington Rand has finally taught the Univac and its descendants to read and speak a little English. In effect, 30 basic words, each representing a frequently used logical operation such as "compare," "less than," "stop," etc., are pre-programmed into the computer so that it "understands" them. Thus, you who have come to depend on a complex logic machine will no longer have to choose between learning machine language or putting blind trust in a programmer to accurately reproduce your problem in machine language. The new system also reduces tremendously the amount of time and effort required in programming. As a result, it is much easier to catch programming errors before the machine has a chance to embarrass you—and you get your answers a lot more quickly. Pretty soon it may be easier to talk to these machines than to other people—and they're so logical, too.

Worn-out Secrets *Can* Serve Again

A few months ago in this column I deplored the fact that the State Dept. had found no harmless use for its worn-out secrets and consequently burned about 2,000,000 lb of them a year. Now I'm happy to report that the Defense Dept., who has even more secrets (about 2,600,000 lb per year), has solved this burning problem. It runs its classified waste paper through a machine that grinds up the secrets beyond recognition. The chewed-up paper is then made into cardboard for cartons. I respectfully suggest that if the State Dept. would adopt the same practice, it could eliminate the $40,000 incinerator it is planning for the new State Dept. building.

Hula Hoopala

There's no question about it, the hula hoop is big business for the plastics industry. Estimates are that 10 to 12 million pounds of plastic will be used for hoops this year. The new high density polyethylenes and high impact styrenes are the plastics being used.

The hoop craze is a stroke of sheer luck for high density polyethylene producers. It couldn't have come at a better time. Besides providing an immediate market for all of the new polyethylene plants, the producers agree that the hoops are providing an unexpected opportunity for evaluating and improving their production techniques.

Tight Pants Can Be Dangerous

There seems to be no end to the frightening discoveries being made on the effects on humans of such things as cigarettes, radiation, smog and sun spots. About the only pleasant discovery we have heard about lately is that whiskey is among the best of pain killers—a fact many of us were already well aware of. On the gloomy side, we have been told that cigarette smoking shortens life and increases the possibility of lung cancer, that getting one's feet x-rayed when buying a pair of shoes can be dangerous, and that sun spots cause depression in some individuals.

Now on top of all this, a recently published report points out that the amount of radiation received from luminous-dial watches can be more than one hundred times that presently received from radioactive fallout. And because wrist watches are usually held somewhere close to the waist, the potential danger to the reproductive organs is obvious.

But of even greater concern to us men are the findings of Swedish researchers on men's clothing. They report that the relatively tight trousers worn by Americans and Europeans increase body heat around the male sperm cells about 5°F. This increase in heat might be responsible for almost half of the present spontaneous mutation rate in genes. Since mutant genes can cause defective offspring, the scientists suggest that we think about making some changes in the design of men's clothing. One of their suggestions is replacing trousers with something similar to Scottish kilts.

What frightens me most about this whole business is that it could lead to the sack look in men's fashions. A less drastic change and a far simpler solution would be for all of us just to wear baggy pants.